Science & Mechanics

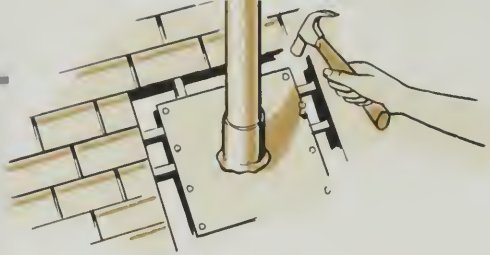
# Complete HANDYMAN ENCYCLOPEDIA

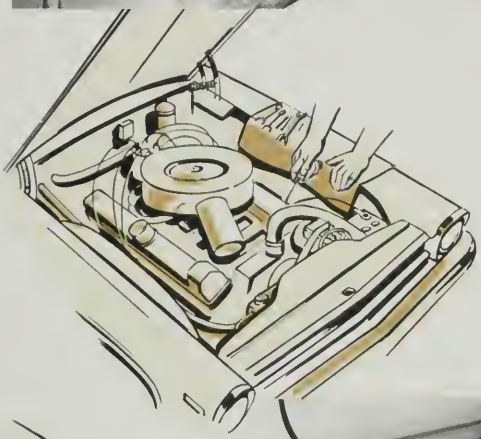
14

PLASTICS, FABRICATING
REPAIRS, AUTOMOBILE

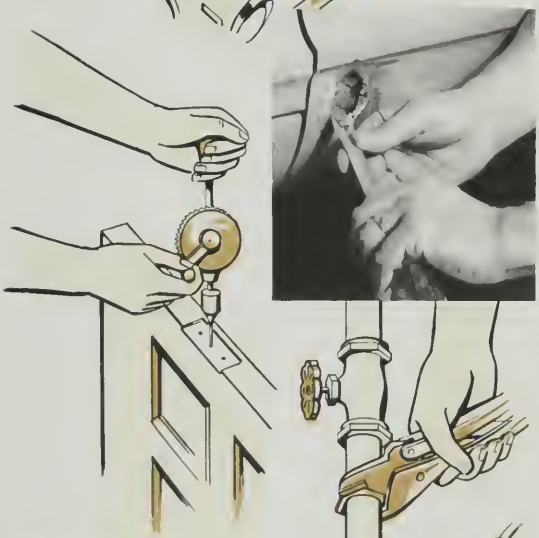
do-it-yourself

# Complete Handyman do-it-yourself Encyclopedia





# do-it-



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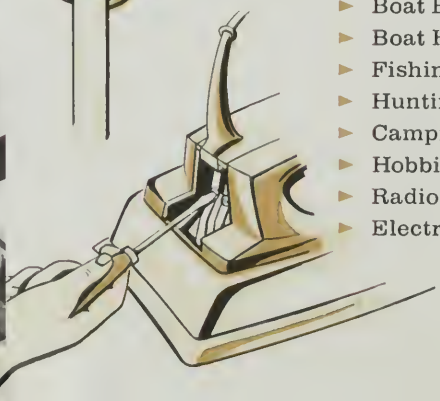

# Complete Handyman yourself Encyclopedia

A COMPILATION OF SPECIAL INTEREST PROJECTS AND MANUALS FOR THE REPAIR AND CARE OF HOMES, AUTOS, APPLIANCES, HOBBY EQUIPMENT.

*by the editors of*

**Science & Mechanics**

14

PLASTICS, FABRICATING
REPAIRS, AUTOMOBILE

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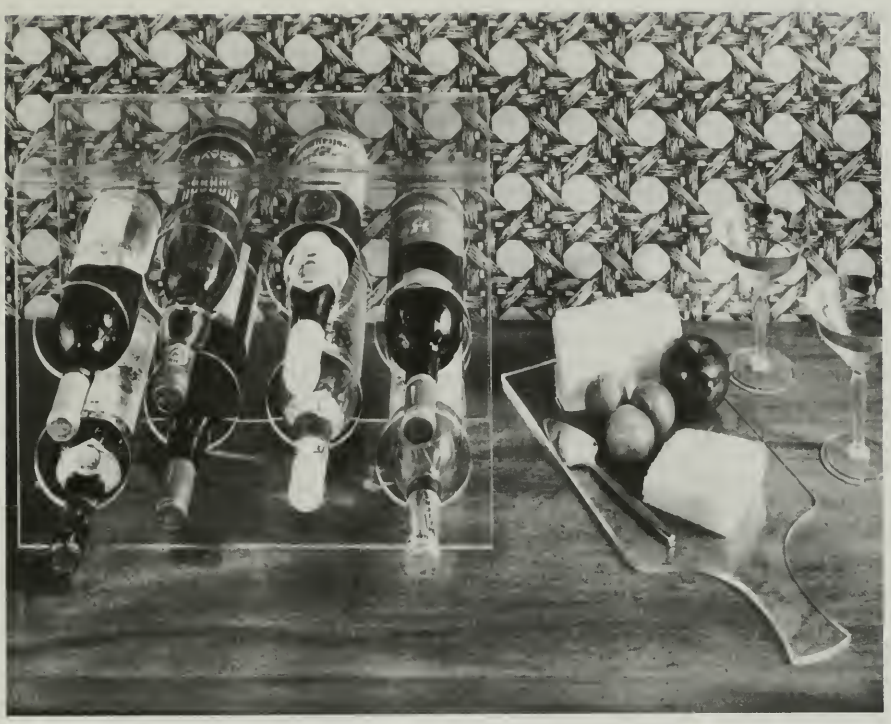


# How to Make a Wine Rack of Acrylic Sheet

**The glossy sheen of this modern design makes it a handsome addition to any decor**

THIS HANDSOME WINE RACK can be made of clear acrylic sheet without difficulty by the average home craftsman, although there is one step that requires more than ordinary skill. This is the heating and bending of the acrylic, but you can learn this technique by practicing on a few pieces of scrap.

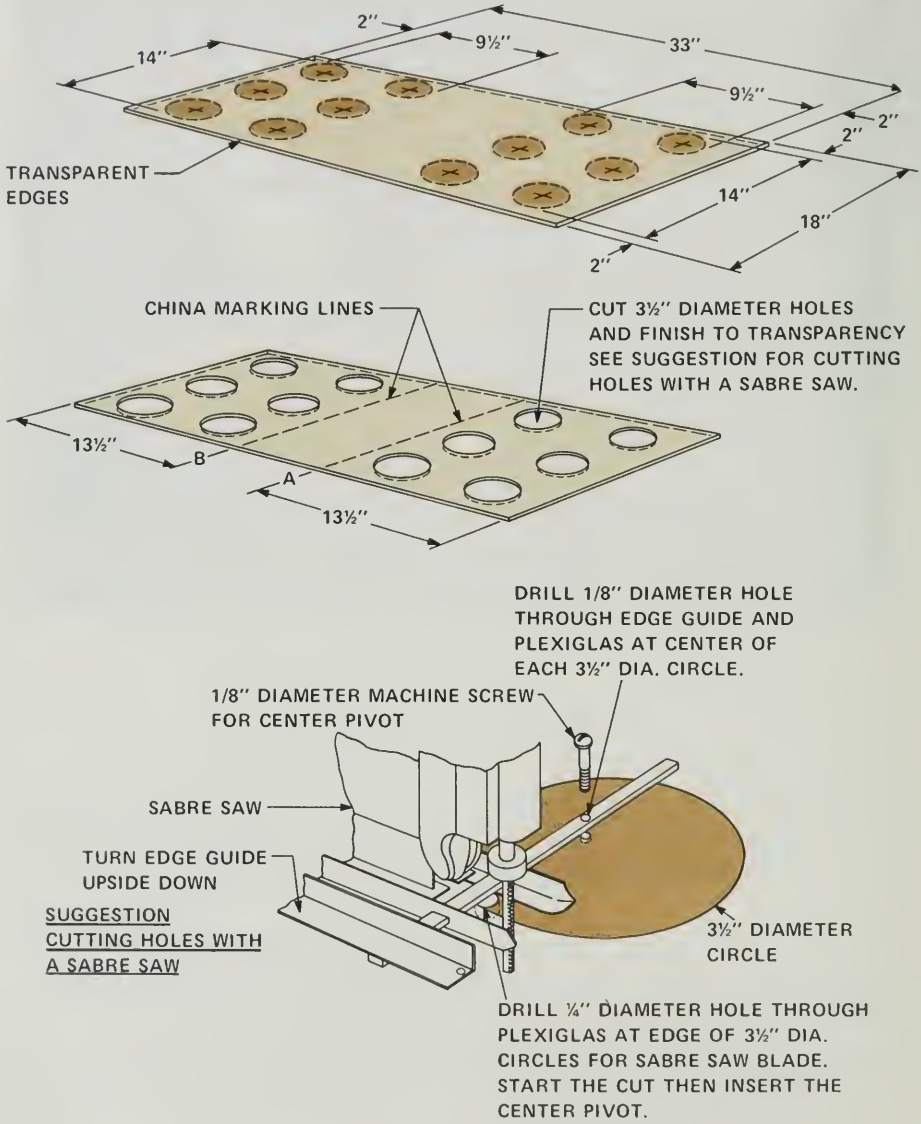
Otherwise, this project is a simple one and requires no unusual tools. The acrylic sheeting is available at hardware stores and lumber yards. It comes with protective masking paper covering both sides. Do not remove this paper until you have completed cutting and drilling the sheet and finishing the edges.

Any kind of power saw can be used to cut the acrylic to the dimensions shown in the drawings, but use the same kind of blade that is used to make fine finish cuts in plywoods, veneers and laminates. Mark the cuts on the masking paper and saw as you would any other material, taking care not to force the tool through the work. Easy does it.

To drill holes for a saber saw or jig saw, to cut out the circles, you can use an ordinary twist bit, but only at a low speed. If your power drill only operates at high

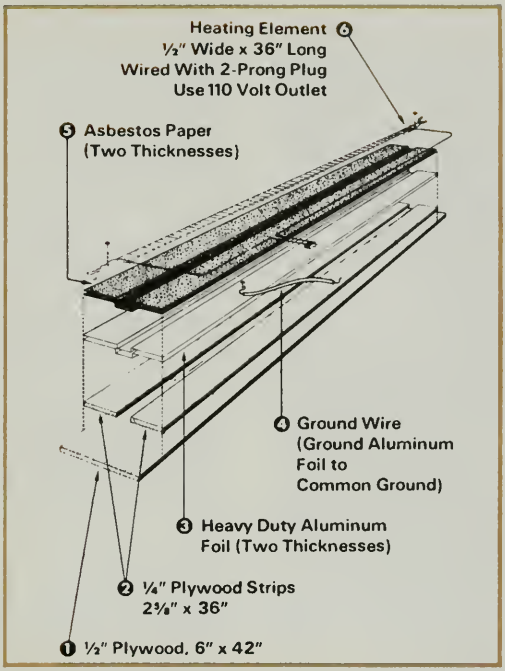
**platform, microscope:** see photomicrography

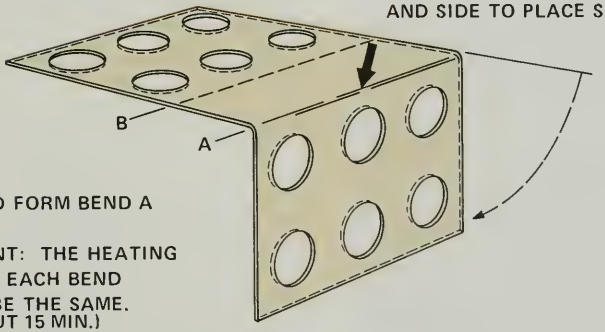
*2010* *How to Make a Wine Rack of Acrylic Sheet*


2"
9½"
33"
14"
9½"
2"
2"
TRANSPARENT EDGES
14"
18"
2"
CHINA MARKING LINES
CUT 3½" DIAMETER HOLES AND FINISH TO TRANSPARENCY SEE SUGGESTION FOR CUTTING HOLES WITH A SABRE SAW.
13½"
B
A
13½"
DRILL 1/8" DIAMETER HOLE THROUGH EDGE GUIDE AND PLEXIGLAS AT CENTER OF EACH 3½" DIA. CIRCLE.
1/8" DIAMETER MACHINE SCREW FOR CENTER PIVOT
SABRE SAW
TURN EDGE GUIDE UPSIDE DOWN
SUGGESTION CUTTING HOLES WITH A SABRE SAW
3½" DIAMETER CIRCLE
DRILL ¼" DIAMETER HOLE THROUGH PLEXIGLAS AT EDGE OF 3½" DIA. CIRCLES FOR SABRE SAW BLADE. START THE CUT THEN INSERT THE CENTER PIVOT.

speed, use a hand drill, or purchase a special bit designed to cut plastics at high speed.

When the cutting is completed, finish all the edges to transparency. This is done by removing tool marks with medium-grit sandpaper, then polishing with wet-or-dry abrasive, then proceeding in steps to 400-

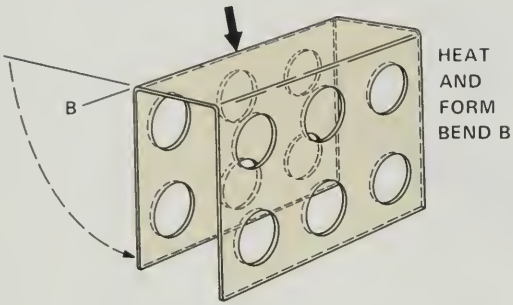



grit abrasive. Use a flat sanding block for the outside edges and a round one for the inside edges of the circles.

When the sanding is complete, buff with a muslin wheel dressed with a fine grit buffing compound and then with a clean flannel wheel.

The wine rack can now be folded into




shape. This is the tricky part and requires a special tool, a strip heater. This is a double length of resistance wire mounted in asbestos and aluminum foil. It can be bought where you purchased the plastic.

Draw a line with a grease pencil, or china marker, across the wine rack 13 inches from each end. These lines mark the place where the plastic is to bend.

Plug in the heating element and place the wine rack over it so one of the lines is over the element.

The plastic must be heated until it is soft. If it is not hot enough, it will craze and form small internal cracks at the bend. If it overheats, it will bubble and scorch.

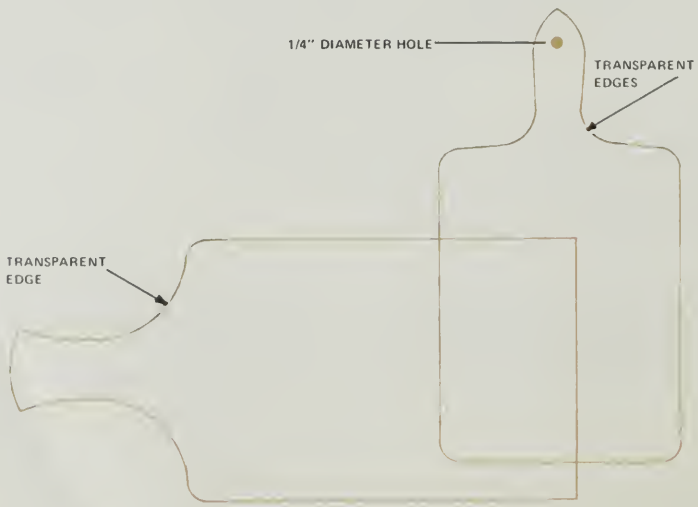
You can tell when the plastic is soft enough to bend by applying very slight pressure. If it feels stiff, stop immediately and wait. If it yields easily with little resistance, it is ready. Judging when the plastic is ready to bend is the most difficult part of this project. Experiment on scrap pieces until you get the feel of it.

When you have mastered the bending technique, you are ready to bend the wine rack itself, but remember one more important point. Always make the bend so that the side of the plastic next to the heater forms the outside of the bend. This is because the plastic on the outside of the curve has to stretch more than the inside portion of the curve and so must be the hottest.

When you have made the two folds, the wine rack is completed. If you started with a fairly large sheet of acrylic, you may have enough left to make a cutting board. This is a straightforward job of cutting out the shape you want and finishing the edges. If you do not choose to finish the edges to transparency, be sure to smooth them anyway, and round the edges slightly. This will prevent the plastic from cracking.

Painting a design on the underside of the board is easy. Trace the design on the masking paper, then cut away the area you want covered with paint with a razor blade. Spray the exposed surface of the plastic with acrylic paint from an aerosol can. Use several coats, according to the instructions on the container. F.C.

*See also:* ABRASIVES; GAME BOARDS.



# Build This Plastic Etagère

**The clean, simple lines of this contemporary piece adapt well to almost any style of interior design**

SLEEK AND SIMPLE, this transparent plastic étagère will fit easily into a contemporary room or serve as an unobtrusive contrast for the furnishings of a period design.

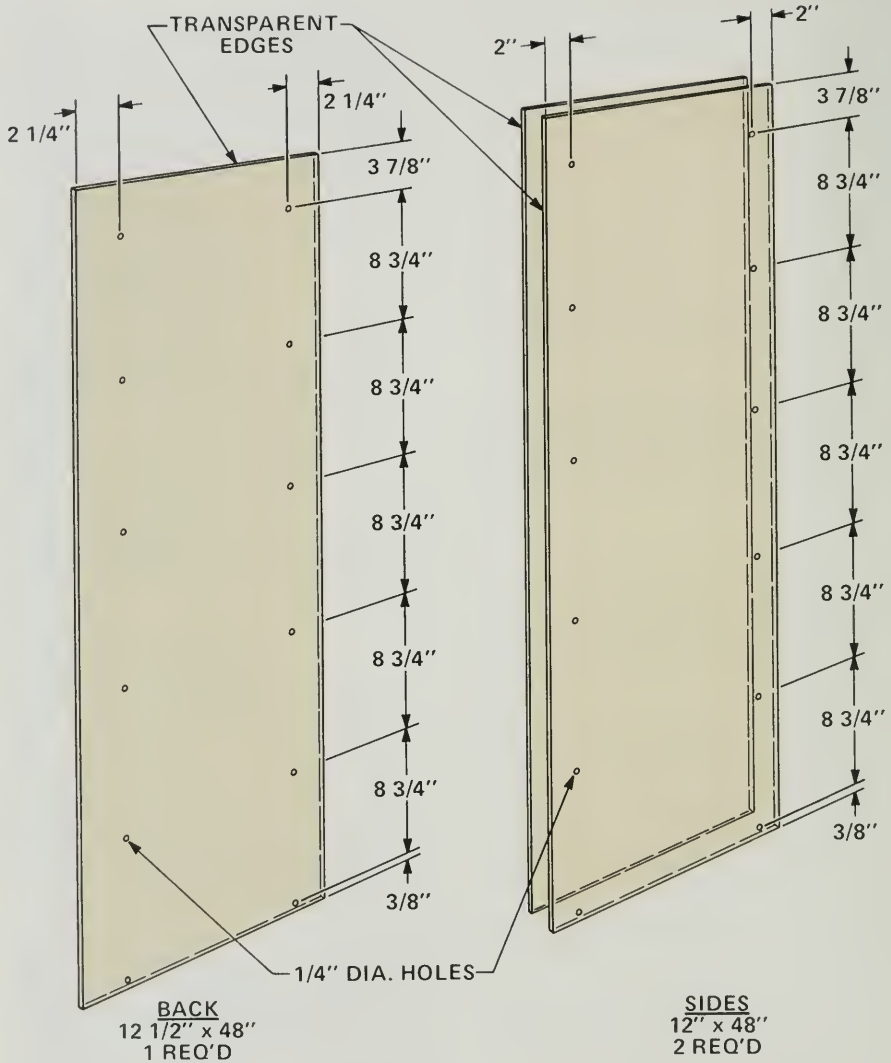
It is simple to make. It requires three panels of clear acrylic sheet, six painted or laquered plywood squares and 36 chrome-plated screws and washers.

First cut the ¼-inch acrylic sheet into three panels, according to the dimensions in the drawings. Leave the protective masking paper on the acrylic while cutting it as well as while drilling it and finishing the edges.

The cuts can be made with any kind of power saw. Use a blade of the same type used for sawing finish cuts in plywood and laminates.

You can use a power drill and an ordinary metal twist bit to drill the holes if your power drill can operate at very low speed. Otherwise, use a hand drill or purchase a special high speed bit for plastics.

After each sheet is cut and drilled, finish each edge to transparency. Start with me-

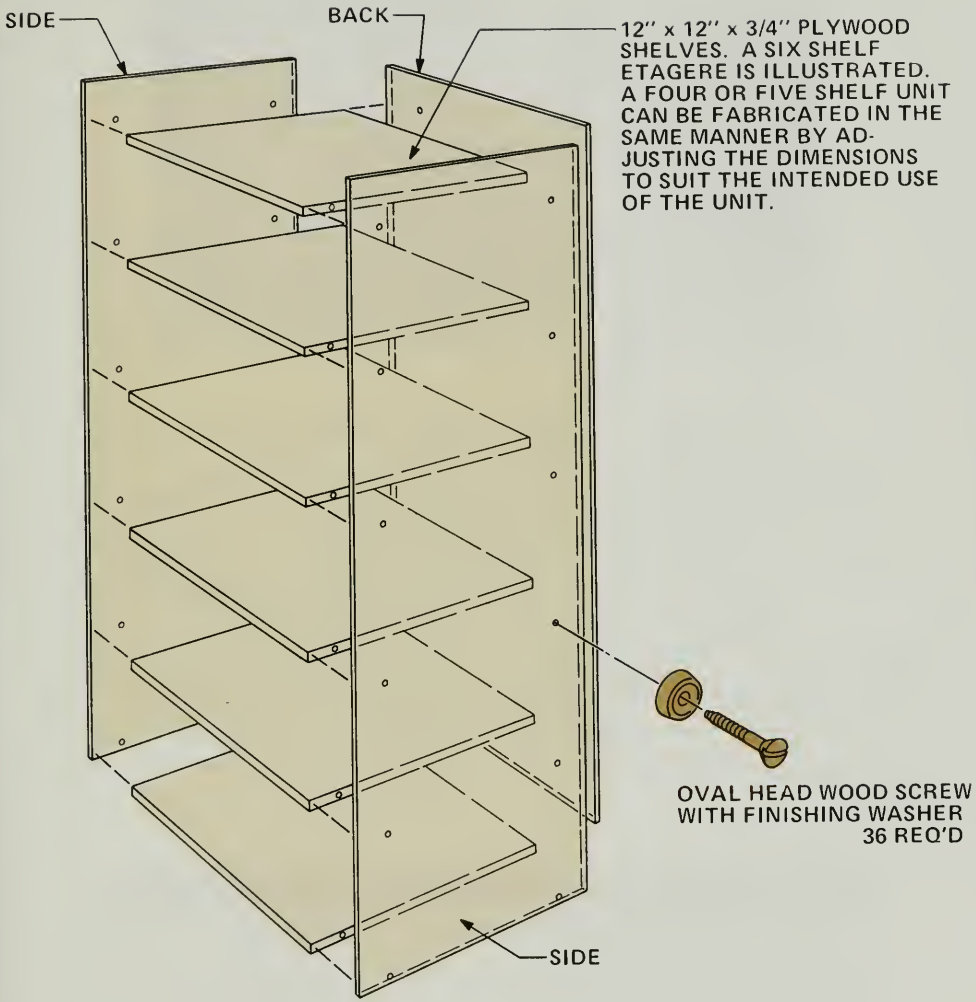



dium-grit sandpaper to remove tool marks. Then, go to wet-or-dry abrasive in steps to 400-grit abrasive. For a final polish, buff the edges with a muslin wheel dressed with a fine-grit polishing compound and finish it with a clean cotton flannel wheel.

Cut six 12-inch squares of ¾-inch plywood, sand them and give them a high-gloss finish. Caution: allow them to dry thoroughly before assembling the étagère. Some paint solvents can damage the acrylic, so give them plenty of time to evaporate.

Pre-drill holes for the screws in the plywood squares and assemble the étagère. Use

*Build This Plastic Étagère* 2015


SIDE
BACK
12" x 12" x 3/4" PLYWOOD SHELVES. A SIX SHELF ETAGERE IS ILLUSTRATED. A FOUR OR FIVE SHELF UNIT CAN BE FABRICATED IN THE SAME MANNER BY ADJUSTING THE DIMENSIONS TO SUIT THE INTENDED USE OF THE UNIT.
OVAL HEAD WOOD SCREW WITH FINISHING WASHER 36 REQ'D
SIDE

## ASSEMBLY

No. 8 or No. 10 chrome-plated one-inch oval head wood screws and chrome-plated finishing washers. Many hardware stores carry this kind of screw, but if yours does not, you can obtain them at a marine supply house.

Turn the screws only enough for them to feel snug. Over-tightening them can damage the plastic.

This design is for an étagère with six shelves, but you can alter it to use four or five shelves, depending on the way you want to use it. F.C.

*See also:* ABRASIVES; GAME BOARDS.

# Build an A-frame Playhouse

**This design can be combined with a sandbox to delight little children**

THE A-FRAME STRUCTURE is sturdy, versatile and easy to erect. It has been used in ski lodges, mountain retreats, summer cottages, lakeside cabins and second homes. Smaller versions have won acceptance as guest houses, hunters' shacks and tool sheds.

Here the A-frame is pressed into service for a child's playhouse. It features a roomy play area, steps, a slide and a large sandbox. Any child would be delighted to have such a wonderful place to play.

It is made entirely of redwood lumber and plywood and can be erected over several weekends, depending on how much experience you have, how hard you work and how much help you have.

Complete plans for building the structure are included.

*See also:* DECKS; LANDSCAPING; PATIOS.

**MATERIALS LIST**

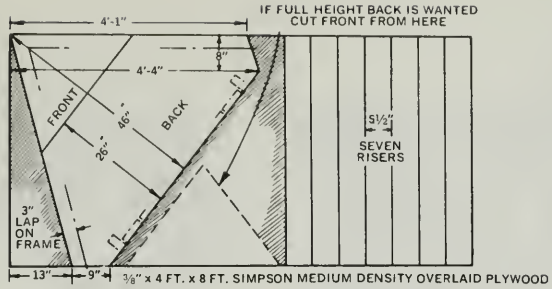
| Quantity | Size and Description | Purpose |
|---|---|---|
| 4 | 2″ 6″x6′ redwood | A-frames |
| 8 | 2″ 6″x4′ redwood | stair treads |
| 4 | 2″ 4″x6′ redwood | spreaders and floor edgers |
| 4 | 2″ 2″x4′ redwood | slide supports |
| 2 | 2″ 8″x6′ redwood | sand box sides |
| 2 | 2″ 8″x4′ redwood | sand box ends |
| 7 | 1¼″ 6″x6′ redwood | deck planks |
| 1 | ⅜″ 4′x4′ medium density overlaid plywood | slide |
| 1 | ⅜″ 4′x8′ medium density overlaid plywood | front, back and risers |

**NOTE:** Also need galvanized nails.

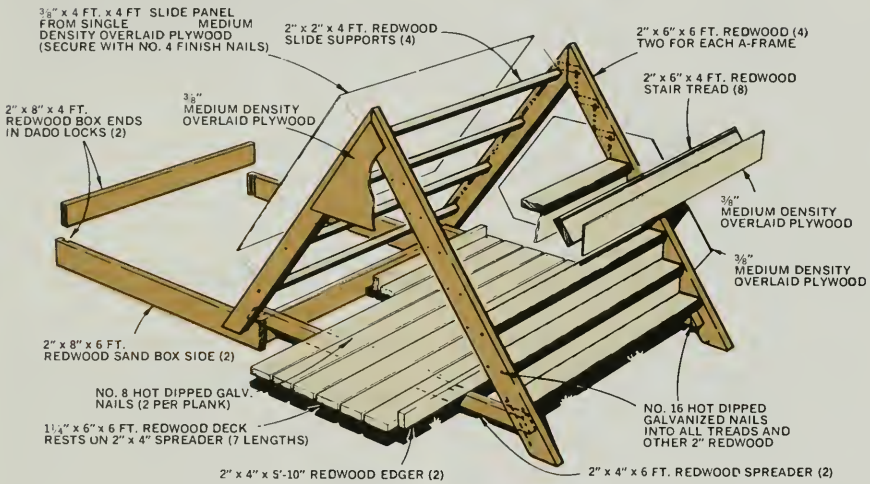
**pliers:** see hand tools
**plumb bob:** see hand tools
**"plumber's friend":** see drains

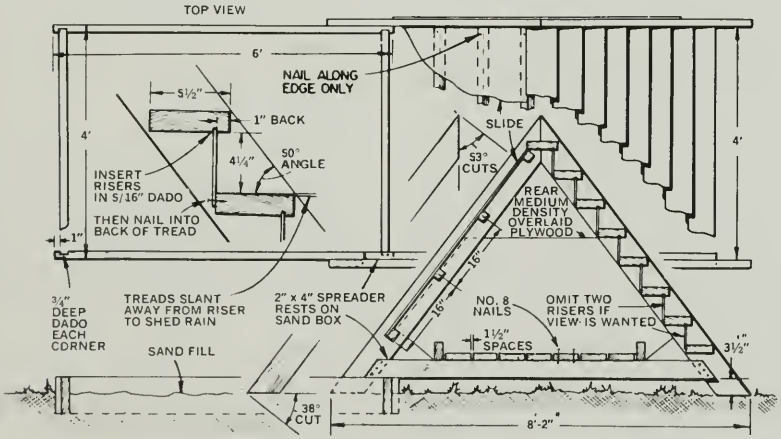
# PLAYHOUSE

*2017*




All redwood should be construction heart grade or better. Sizes of the project can be modified if desired, but in this event, complete new drawings should be made to verify all dimensions.


⅜" x 4 FT. x 4 FT. SLIDE PANEL FROM SINGLE MEDIUM DENSITY OVERLAID PLYWOOD (SECURE WITH NO. 4 FINISH NAILS)
2" x 2" x 4 FT. REDWOOD SLIDE SUPPORTS (4)
2" x 6" x 6 FT. REDWOOD (4) TWO FOR EACH A-FRAME
2" x 6" x 4 FT. REDWOOD STAIR TREAD (8)
2" x 8" x 4 FT. REDWOOD BOX ENDS IN DADO LOCKS (2)
⅜" MEDIUM DENSITY OVERLAID PLYWOOD
⅜" MEDIUM DENSITY OVERLAID PLYWOOD
⅜" MEDIUM DENSITY OVERLAID PLYWOOD
2" x 8" x 6 FT. REDWOOD SAND BOX SIDE (2)
NO. 8 HOT DIPPED GALV. NAILS (2 PER PLANK)
1¼" x 6" x 6 FT. REDWOOD DECK RESTS ON 2" x 4" SPREADER (7 LENGTHS)
NO. 16 HOT DIPPED GALVANIZED NAILS INTO ALL TREADS AND OTHER 2" REDWOOD
2" x 4" x 5'-10" REDWOOD EDGER (2)
2" x 4" x 6 FT. REDWOOD SPREADER (2)



# Householder's Guide to Plumbing

**Here's how to get to know your house's plumbing system before things go wrong and what to do about emergencies when they arise**

THE COMMODE BEGINS to overflow and no amount of jiggling of the control stops the water from edging toward wall-to-wall carpeting. Or it may be the sudden bursting of a pipe, an out-of-control faucet or an overflowing washing machine.

Such emergencies are inconvenient and can cause damage running into thousands of dollars, if corrective action is not taken immediately. Being prepared for plumbing emergencies is simple, but rarely understood in most homes. A few minutes of your time now could be insurance for future security, and trouble-free performance of your water system.

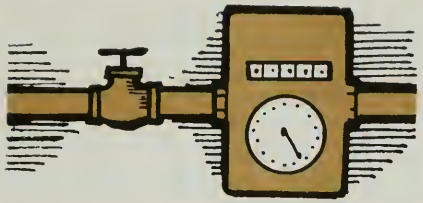
*Discovery tour.* When your plumbing system was installed, the contractor usually anticipated possible emergencies by placing a series of shutoff valves throughout the home. For the tour, you should take along a flashlight, adjustable wrench and a set of color-keyed tags for labeling every control.

*Kitchen shutoff valves.* Below your kitchen sink you will find shutoff valves for both the hot and cold water. In some cases, the valves will be below the kitchen in the basement. Craftsman plumbers sometimes install the valves both below the sink and also in the basement.

*Bathroom valves.* Valves are provided for the lavatory, commode, and the bathtub. The lavatory valves usually are below the fixture for easy access. Tub valves can be in the basement or behind an access plate in back of the faucet controls. The commode or water closet has a single cold water valve normally installed below the water tank.

*Other valves.* If you have a hot water heating system, you will find a cold water shutoff valve near the furnace.

**plywood:** see lumber
**plywood boat:** see boat building
**pocketknife:** see knives and axes
**polishing:** see abrasives
**pollution control:** see anti-pollution



Each radiator also has individual shutoff valves on one end of the unit.

Just about all that's left, serviced by water, is the washing machine and the hot water heater. Both, you will find, have shutoff valves conveniently located on or near the appliance.

*Main shutoff valves.* The water line coming in from the street almost immediately is connected to the water meter followed by a master shutoff valve for the entire home. Close this one valve and you have shut off water throughout the house—it is instant action for serious emergencies.

*Locate and test every valve.* You are ready for any water emergency when you know where the valves are located for all your faucets and appliances. Plan a house tour and include older children, who should also know what to do if water emergencies arise when they are alone in the house.

Start with the main water line valve, which totally controls the flow of water in your home. Usually, it is in the basement and often in a hard-to-find obscure location. Find the valve, be sure it operates freely and apply a tag to the main water line. If it is especially hard to find, place a second tag in a more visible spot.

Continue the same procedure with the kitchen. Find the valves below the sink and test to see if they open and close easily. It is especially important to make this check because over a period of time, a valve can become "frozen" if not used for years. Usually a wrench applied to the control wheel will free up the valve. Do this carefully to avoid breaking the control head. If the control just can't be moved, it is usually best to have it serviced by your plumber. Until this is done, make a mental note to shut off the main water line valve, if this section of your plumbing gives trouble. After moving and freeing the valve, check for possible leaks around the stem. Minor leakage can be stopped by applying a wrench to the cap or packing nut. Finally, apply your tags—"Hot Water—Kitchen," and "Cold Water—Kitchen," etc., to the control valves.

Continue the water tour—the bathroom or bathrooms, bathtub, heating plant, water heater, water softener—every place in the home where water is used. Label all controls with proper identification tags.

To repeat, locating the main shutoff valve is especially important because when closed, it stops all water throughout the house in seconds. Be sure that everyone, including the children, know where this vital control is located.

*Basic tools.* Here's all that is needed to make simple plumbing repairs: wrenches—a medium-sized pipe wrench and an adjustable end wrench; screwdrivers—in a range of sizes to fit faucets, valves and other parts of the system; head screws for faucet handles usually call for screwdrivers suitable for Phillips screws; adjustable pliers; rubber force cup or plunger; cleanout auger ("snake"); pipe joint compound; plumbers putty—used for reseating the drain on sinks when leaks develop or when a new drain is installed.

*Vacation safeguards.* Closing the main water shutoff valve before leaving for a vacation is recommended. Emergencies do arise when the house is unattended, and a periodic visit by a neighbor is of limited value. In winter months, a daily visit by a neighbor while you are gone is suggested. If the home is vacated for an extended period or a neighbor is not available, you can have your water system completely drained to prevent freezing. This should be done professionally by a qualified plumber.

*Water stoppages, dropped objects.* Drains may become clogged by objects dropped into them or by accumulated grease and other matter.

If a ring, for example, is dropped in the kitchen sink and can't be retrieved, the fixture trap can be easily removed. Do not run water or try anything else.

Below the sink drain, you will find a large, curved pipe called a "fixture trap." The drained water runs into this trap and objects are literally "trapped" by the curve in the pipe. Put a pan below the pipe and loosen the two large nuts at either end. Keep turning and the whole curved piece of pipe will drop off in your hands. Note the washers used—they go back when you reinstall the fixture trap. Rings, all sorts of solid objects stop in the trap and if not removed, they gradually obstruct the pipe. Some traps have a clean out at the bottom, so you don't have to take off the pipe.

*Chemicals.* Chemical cleaners should not be used in pipes completely stopped up, because to be effective, they must be in direct contact with the stoppage. Rely on them for only minor stoppage and handle the material with extreme care, following the directions on the container. Keep them out of reach of children, because most of these products contain deadly lye.

*"Plumbers friend."* This is an ordinary rubber force cup or plunger, which can be effective for minor obstructions.

*"Snakes" and augers.* Cleanout auger—long, flexible, steel cables, that are commonly called "snakes" may be successfully run down drainpipes to break up obstructions or to hook onto and pull out objects. Augers are made in various lengths and diameters and are available in hardware and other stores. In servere cases, call your plumber who has professionally-designed, power-driven augers.

*Repairs and maintenance.* Faucets and shutoff valves are very similar in design (see

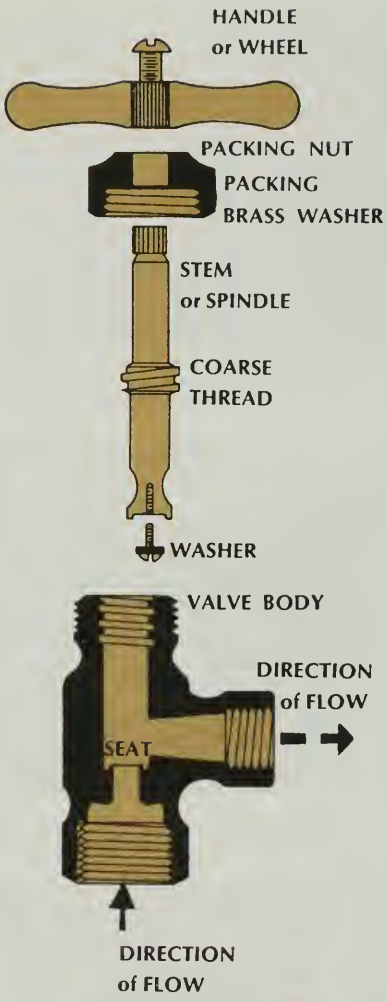
illustration) and repairs are identical. Faucets and valves may vary somewhat in style, but functionally, they are pretty much the same. Mixing faucets found on sinks, bathtubs and laundry tubs, are actually two faucets sharing a common spout. Each unit is independently repaired.

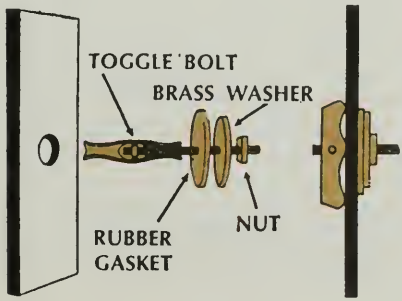
Leaks in tanks, such as water heaters, are usually caused by corrosion. Sometimes, a safty valve may fail to open and the excessive pressure will spring a leak.

While a leak may occur at only one place in a tank wall, the wall may also be corroded thin in other places. Therefore, any repair must be considered as temporary, and the tank should be replaced.

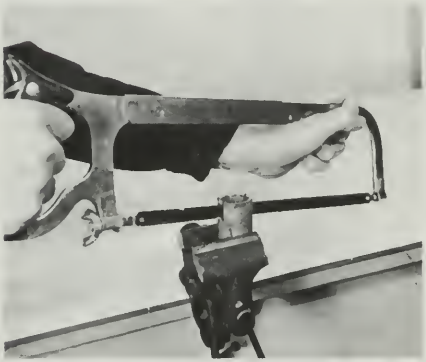
Faucets in the past all had washers to control the flow of water. If a faucet drips when closed or vibrates, "sings" or "flutters," when opened, the trouble is usually the washer at the lower end of the spindle. If it leaks around the spindle or shaft when opened, new packing is needed.

To replace the washer cut off the water at the shutoff valve nearest the faucet. Take the faucet apart—the handle, packing nut, packing, and the spindle, in that order. You may have to set the handle back on the spindle and use it to unscrew and remove the spindle. Remove the screw and the worn washer from the spindle. Scrape all the worn washer parts from the cup and install a new washer of the proper size and angle. For just the right part, take the old washer to a hardware or other store for matching.



*A tiny leak can develop into a major flood, if the right steps aren't taken to check it.*



*Emergency repair can be made by cutting an oversize coupling in half with a hacksaw.*

*Center C-clamp on pipe and metal pressure plate, then tighten until gasket seals the leak.*

Examine the seat on the faucet body. The washer fits the seat and if it is rough or badly worn around, a new washer won't help the leaking faucet. Your local stores carry a seat dressing tool for refacing faucet seats.

Reassemble the faucet. Handles of mixing faucets should be in matched positions.

To replace the packing, simply remove the handle, packing nut, and old packing, and install a new packing washer. If a packing washer is not available, you can wrap stranded graphite-asbestos around the spindle. Turn the packing nut down tightly against the wicking.

*Emergency repairs.* Anything from an occasional single drop of water to a deluge from the pipes can create a household crisis. It's bad enough when the leak occurs in the basement mains, but the real woe comes from a leaking pipe concealed inside a wall, where damage is twofold, from the water and ruthless ripping out of the wall to reach the pipe.

Temporarily, several devices will stop a small leak in a pipe. A metal bushing or a short piece of pipe, cut down the middle with a hacksaw, can be used as a patch when held in place with C-clamp pressure. Line the inside of the half-pipe bushing with sheet rubber cut from an old tire tube, to serve as a gasket.

If the pipe wall is otherwise sound, without the effect of corrosion that has weakened the walls, it is possible to seal the leak by drilling the hole a bit larger and tapping it for a screw plug.

Put a soft washer under the screw head so it will be drawn tightly against the rounded pipe surface to seal any water that would bypass the screw threads.

In some pipe leaks, a temporary repair can be made by cutting away the faulty section of pipe and inserting a piece of fabric-lined rubber hose, sealed with shellac and held tightly with outside clamps.

The leaking pipe or tubing should be re-

paired at the first opportunity, even if the patch seems to hold.

Union fittings are the handiest item for this, as you will learn. Make two hacksaw cuts in the pipe near the leak and remove the section. Turn out the pipe from its fittings on both sides.

The repair will be made by joining two pipe lengths with a union. If one of the pipe sections is not very long, it will be better to replace it as that will eliminate need for an extra coupling.

Replacing a defective elbow or tee fitting is done in a similar manner, cutting away a section of nearby pipe so that you can take out the part with the bad fitting, and replace it. The line is reassembled by adding a union at the cut section.

For leaking tubing in the wall, the alternative to breaking into the wall is to cut the tubing at two accessible points, drawing out the entire tube from the wall and snaking a new one into place.

Successive pinhole leaks indicate that the pipe wall has become very thin as a result of corrosion. Minor repairs only stave off the real solution, which is that the entire pipe must be replaced, or installation of a complete new system. Professional advice on this is advised.

If only one or two mains are affected, or if major overhaul of the system must be delayed for a while, then the weakest pipes can be replaced by the methods already discussed.

In making the partial pipe replacement, always check on the end fittings, particularly the elbows, and put in new ones if there's any sign of liming.

With an epoxy you can often make a permanent repair by cleaning the area around the leak with a wire brush, then filling in the opening with a sealing compound.

*See also:* DRAINS; FAUCETS; HEATING SYSTEMS, HOME; LAUNDRY ROOMS; SAUNA; SITE SELECTION; SWIMMING POOL; TOILET.

*Rubber washer on the screw serves as a stopper gasket. Be sure to use a brass screw.*

*Best way to remove pipe between fittings is to cut away a section to permit turning pipe.*

*Leak at pipe joint is harder to control but sometimes it can be stopped with epoxy.*

# Plumbing Tips

**Here are some tips to help you do that plumbing job quickly and correctly**

PERSISTENT CREAKING NOISES usually result from rubbing of a water pipe against a wood beam, or the expansion of a pipe when hot water runs through. Make a test survey of all the exposed pipes to see if any are too close together, or touching a structural house support. Fasten down loose pipes with metal straps wherever they can be reached. Where pipes touch, a partial correction may be obtained by wrapping asbestos cloth or similar insulation material around the pipe.

Chattering or whistling may be traced to a faucet which has a loose washer. Remember that the washer is held in its seat by a short brass screw. Over a period of time, the screw becomes corroded and the stem is smaller than when installed so it doesn't hold the washer tightly. Replacement of the washer and its retainer screw should clear up this difficulty.

Faucets that do not have a replaceable washer seat sometimes can be repaired with a special insert of soft brass which is placed over the old seat to provide a new smooth surface. This may work for a while, but will deteriorate quickly under the constant rotation of the washer.

The best correction is to replace the troublesome faucet with a new one—of the latest type, while you're at it.

*Attaching plastic lines.* When attaching plastic lines to metallic systems, it is recommended that an insert adapter be used. This is attached to the plastic pipe in the same manner as other plastic insert fittings. Threaded end only of adapter is coated with a plastic joint compound and tightened into female connections.

Joint compound should not be used on serrated insert fittings except where the threaded end of such fittings engage metallic pipes.

At such points, a non-hardening joint sealer should be employed. The clamps should be slipped over the pipe before the insert fitting is attached, and the clamp tightened firmly over the cylindrical part of the fitting between the shoulder and the molded serrations. Plastic is not subject to rust or corrosion, is lightweight and easily cut.

*Keep washers on hand.* Whenever you have occasion to replace a washer, make a note of the size washer used for the fixture, so you can buy replacements to keep on hand. Usually, it is not worth buying the usual hardware store assortment because most of the washers included will never be used.

When replacing a washer on a decorative faucet, use care not to scratch or dent the chrome surface. If necessary, protect the finish from the wrenches with a cloth or masking tape.

*Condensation on pipe.* Sweating of water pipes is a persistent and annoying problem. This increased humidity contributes to dampness, odors, mildewing of clothing and metal rusting. The condensation is caused by deposit of moisture from warm air in the room on pipes kept cold by continued drawing of water.

The normal solution is to insulate the

pipe with one of the various tapes, wrappings or pre-formed coverings available. Pipes behind walls and those boxed with wood in finished basements are less subject to condensation.

An electric dehumidifier is valuable to keep down dampness. It can draw gallons of water from the air daily. Chemicals like calcium-chloride crystals are also effective.

*Valve repairs.* There are a number of valves used in the average home system.

Gate valves are usually for the service entrance and the main water branches, as they allow direct passage of the water with minimum drop in pressure. These valves are are intended only for infrequent use, and generally are kept fully open.

Globe and angle valves are used to control the flow of water (for example, the mixing valve at a water heater) and thus are adjusted quite frequently.

Globe valves may leak at the stem, which will require repacking. This is done by loosening the packing nut so it can slide up on the stem sufficiently to allow threading the graphite packing underneath. Pressure of the cap usually seals the space and stops leaks.

When the washer must be replaced, the water main is closed down and the lines drained. The stem is removed similarly to a faucet by turning off the packing nut and bonnet. A composition fiber washer is fitted into the stem cup, held with a brass screw.

Gate valves are usually preferable to globe valves when an unobstructed flow is desired, as globe valves offer about 50 percent more resistance to the flow of water.

Care must be taken when installing valves to have the pipes correctly threaded and screwed into the valve. If the threads are too long, there will be danger of screwing the pipe too far into the valve, striking the valve seat, and ruining it.

Globe valves should be installed so that when closed, the pressure will not be on the stuffing box, but against the stem so the packing can be replaced while there is pressure in the line. If the valve is installed so the flow-through is reversed and the valve disc becomes detached from the stem, it would automatically close the valve.

Pipe hangers should be placed near and on each side of the valve so no strain or weight of the pipe is carried by the valve. A bowed condition will result in unequal strain on the threads and, in time, result in a leak that can only be checked by replacing the valve, pipes or both.

Globe valves should be set with the stem in a horizontal position when possible. Gate valves should be set with the stem in a vertical upward position, or at a 45° angle so scale and sediment will collect on the bottom.

*Unclogging lavatory sink.* When pop-up waste plugs become clogged and can't be entirely cleaned from the top, loosen retainer nut underneath sink. Also release adjustable tie rod by turning out any retainer screw or pin. Pull out lift rod and plug. Clean thoroughly.

When a drain becomes stopped up, try inserting one end of an old broken banksaw blade, pushing it down as far as possible, then twisting it slightly as you pull it out. It may save you the time and cost involved in calling a plumber.

*Cutting pipe correctly.* Clamp the pipe securely in a plumber's vise with the part of the pipe to be cut as close as possible to the bench edge. Mark the cutting position on the pipe with pencil and cut it with a pipe cutter. For a clean cut, take steady turns with the cutter, tightening the wheel screw moderately as you make each turn.

Avoid extreme pressure of the cutting wheel, as that will dent the pipe end excessively. After cutting, ream the end to remove the burr to leave a smooth surface inside. Tap the pipe to knock out any metal chips.

*See also:* DRAINS; FAUCETS; HEATING SYSTEMS, HOME; TOILET.

# Build Your Own Pool Table

**This project requires time and a well equipped workshop, but if you enjoy woodworking it will afford you many hours of pleasure while you are building it as well as after it is completed**

A POOL TABLE is not a simple piece of work that a beginner can put together on a weekend. But, for someone who enjoys woodworking, this challenging project will provide many evenings of pleasure while it is being made as well as after it is completed.

Start by constructing the two pedestals. Lay out the end pieces, or legs, on your stock and cut four identical pieces, as shown in the drawing. Use ¾-inch stock. All wood used in the project, except of course for the plywood, should be well seasoned or kiln-dried. Pine is suitable.

Attach the ¾ x ¾-inch pine cleats to the legs, setting each in ⅛-inch from the edge to accommodate the pedestal skin. Then attach the two horizontal crosspieces, one at the bottom and one part way up the leg, as shown in the drawing. Use nails and glue to do this.

Next, attach the two gum plywood skin panels. Each front panel is ⅛ x 20 x 28½-inch gum plywood. The two back panels are ⅛ x 21 x 28½-inch gum plywood.

The skin panels are held in place with glue and brads. When the glue is set, the corners of the pedestal can be rounded, if you wish. Insert a T-nut leveler at each corner, as shown in the photo, so the table can be leveled precisely when it is used for play.

When the pedestals are finished, cut out the parts for the bed support (parts A through G) from ¾-inch fir plywood as shown in the drawings. The bed, ball tunnel and gulleys are all assembled right on the pedestal. Start by screwing Part B to the tops of the legs of each pedestal. Each Part B goes outside the pedestal legs.

Attach the long cleats to the inside bottom of each tunnel wall (Part A). Then

**porch:** see additions, home
**porch seats:** see early american
**porch steps:** see brickwork
**pottery:** see ceramics
**power brakes:** see drum brake service

assemble bed support and ball tunnel and gulleys. The surest way to do this is to assemble the structure temporarily, merely tacking the parts together lightly or holding them with clamps and scrap pieces of wood. This will enable you to see how everything goes together and make sure all the parts fit.

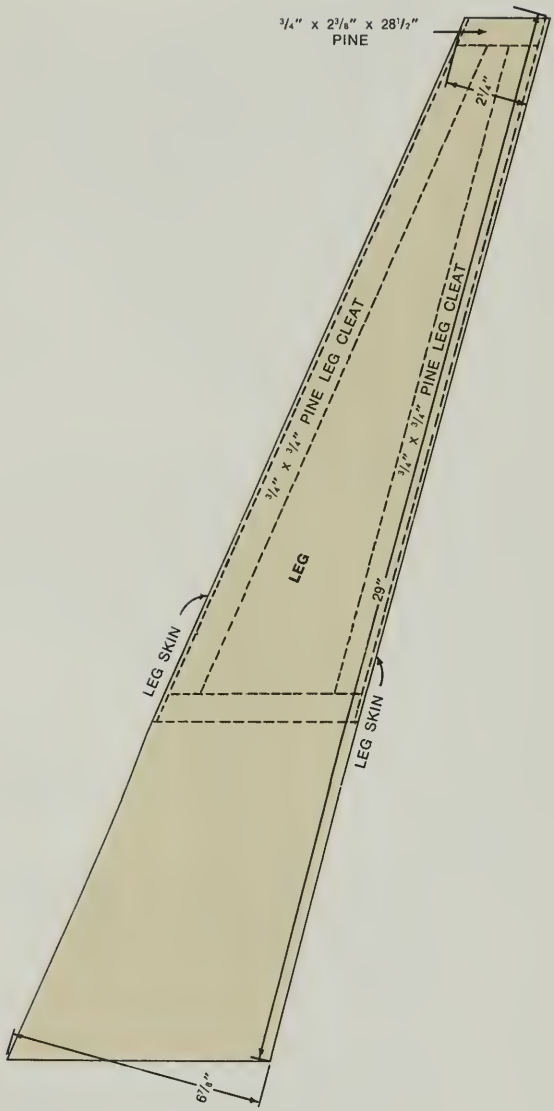
When you are satisfied that everything is in order, reassemble the bed support with glue, nails and screws. Also build the gulleys.

When cutting parts C and D as well as the corner apron formers, pay careful attention to the mitered notches that will accommodate the corner pockets. See the drawings for details of how to cut these notches. Also, be sure to check the fit of the pocket liners in place before the table bed is finally assembled.

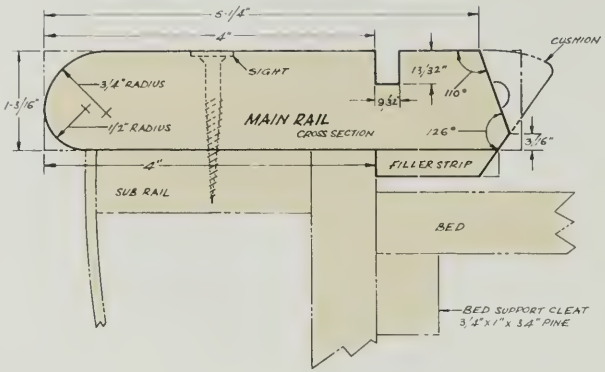
Once the bed is constructed, cut the subrails out of ¾-inch pine stock, according to the dimensions in the drawing. Attach the end and side subrails flush with the tops of the end and sides of the apron pieces with screws and glue.

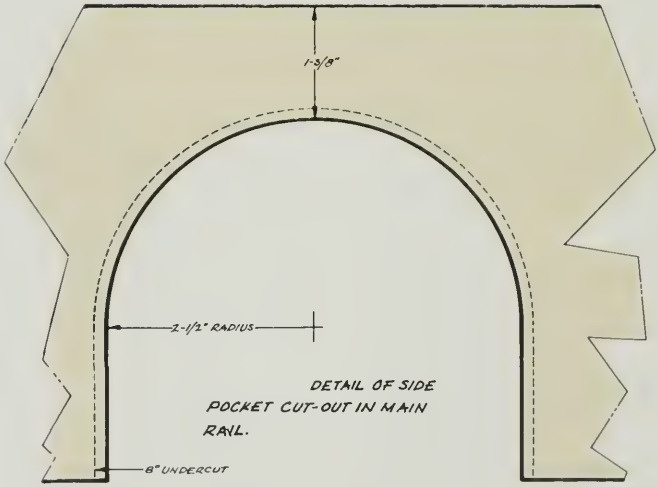
While the subrail glue is setting, cut 22 apron formers of ¾-inch pine, as shown in the drawing. All of these formers are notched at the bottom to receive the apron retainer strip. Four of the 22 are also drilled and countersunk for two screws each (see drawing) and given a mitered notch at the top to accommodate the corner pockets. Make two with right-hand notches and two with left-hand notches. The corner detail drawing and the apron former detail drawing illustrate how this should be done.

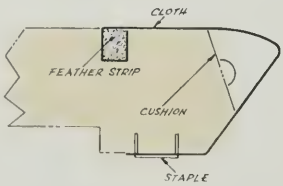
Screw and glue the apron former pieces to the apron side and end pieces. The four corner formers are screwed to the side pieces through the drilled holes. The 18 other formers are glued and attached with screws driven from the inside through the end and side pieces and from the top through the subrail into the formers.



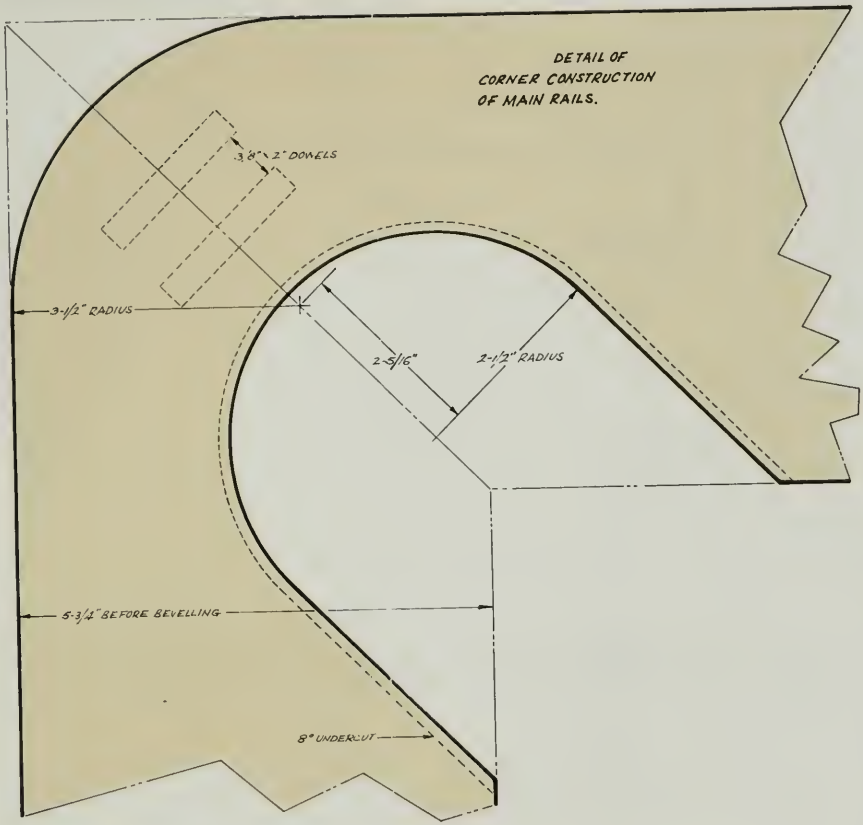

Shape and groove ½ x 1½-inch pine strips for the apron retainers as shown in the profile drawing. Make two side pieces each 81½ inches long and two end pieces each 43½ inches long. Glue apron skin retainer strips along the bottoms of the side




CROSS SECTION OF
CUSHION CLOTH INSTALLATION

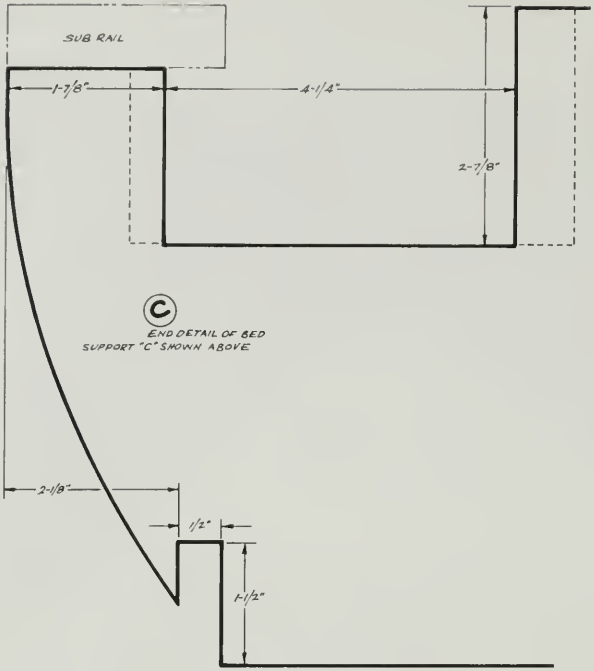


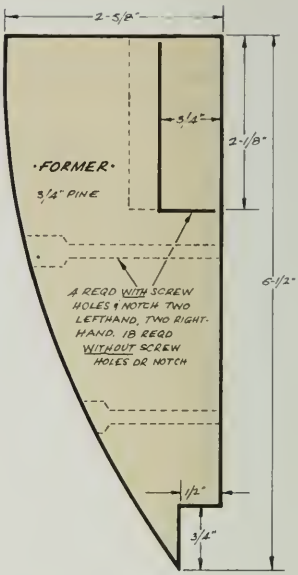

and end pieces, fitting them into the notches at the bottoms of the apron formers. The slanted groove should be on the outside facing upward.

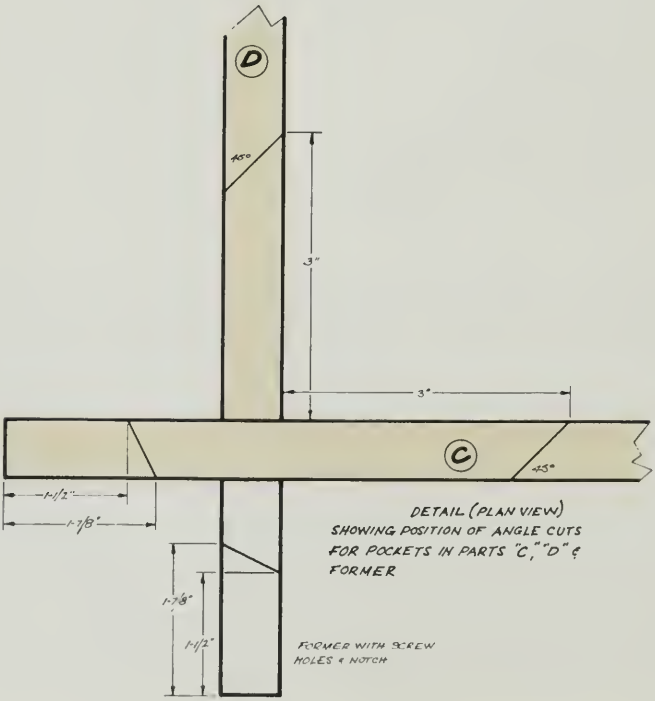
Give the glue time to set. Then, use a scrap piece of ⅛-inch gum plywood to check the width of the apron skin. Cut four strips of gum plywood to this width and to the same lengths as the retainer strips.

To attach the apron skin, run a bead of glue into the groove of the apron retainer. Spread it in the groove with a brush and brush glue on the outside edges of the apron formers and the subrail. Insert one edge of the piece into the groove and bend it up and around the formers. Use a length of scrap wood and clamps to hold the top edge of the skin section against the edge of the subrail. After the glue is set, use a block plane to trim the top edge flush with the top of the subrail, if necessary.

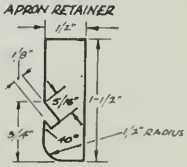
Cut four sets of corner blocks of ¾-inch pine. Each set comprises progressively smaller quarter sections of a pie. Glue them in place, as shown in the drawing. Next, mix a batch of auto body filler (available at any auto supply store) and apply it over the stepped corner blocks. When it is set, sand the filled corner with #80 garnet paper so it forms a smooth, rounded corner



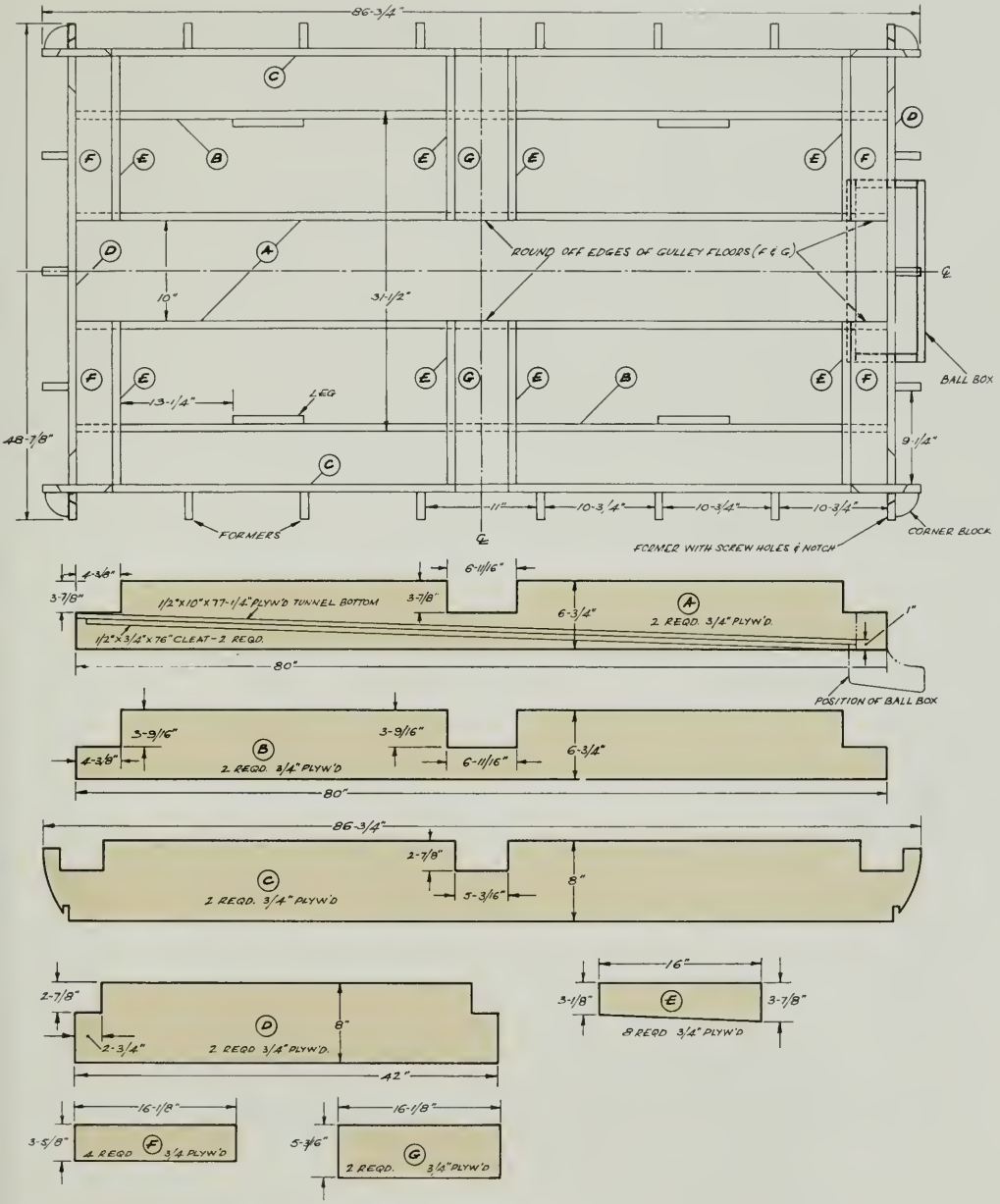



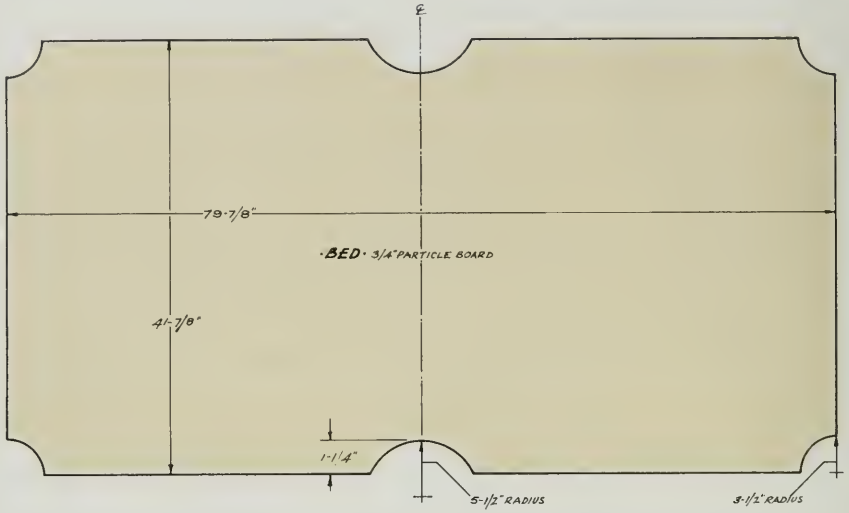



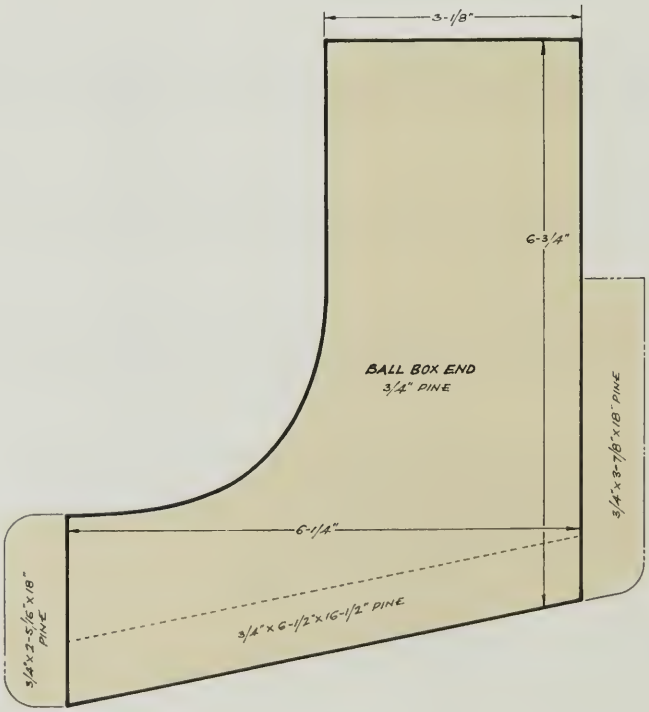

DETAIL (PLAN VIEW) SHOWING POSITION OF ANGLE CUTS FOR POCKETS IN PARTS "C," "D" & FORMER



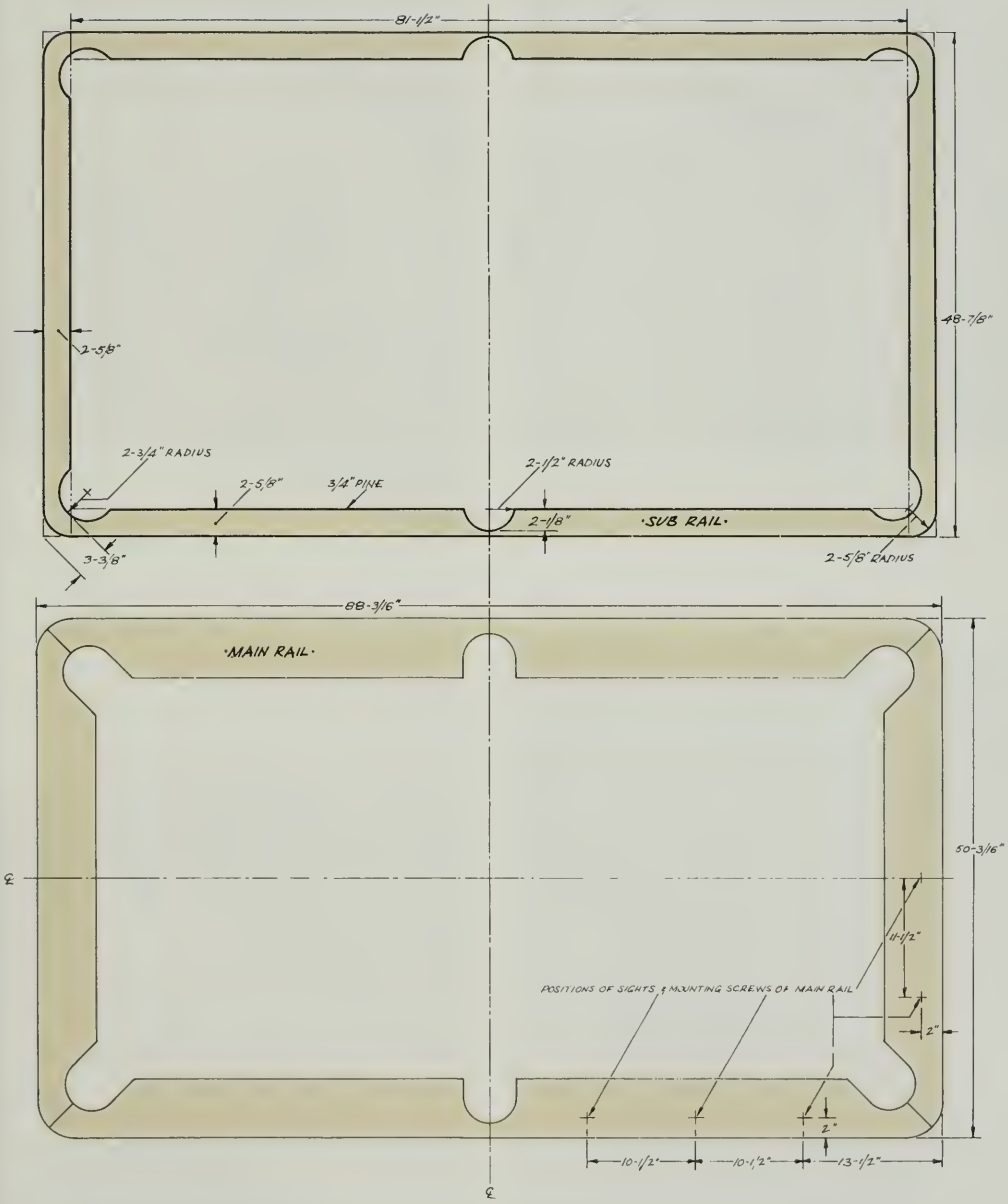
*Build Your Own Pool Table* 2031




℄
79-7/8"
·BED· 3/4" PARTICLE BOARD
41-7/8"
1-1/4"
5-1/2" RADIUS
5-1/2" RADIUS


3-1/8"
6-3/4"
BALL BOX END
3/4" PINE
6-1/4"
3/4" x 6-1/2" x 16-1/2" PINE
3/4" x 2-5/16" x 18" PINE
3/4" x 3-7/8" x 18" PINE

*Build Your Own Pool Table* 2033



*2034*

▲ *Insert T-nut levelers at each end of the bottom of each pedestal. These will enable you to level the table precisely when it is in place and ready for play.*

▲ *Use clamps and scrap wood to assemble the apron and bed support structure temporarily, or tack the pieces lightly in place. This will familiarize you with the way the parts go together and check the fit. When you are satisfied that everything is in order, assemble permanently with glue, nails and screws.*

▼ *Check the fit of the pocket liners before attaching the subrail.*

▼ *The tunnel floor stops short of the apron to allow balls to roll into the ball box.*

▲ *Apron formers are attached to apron rails with glue and screws driven from the inside and from the top.*

▲ *Check the width of the apron with a piece of scrap before cutting the 1/8-inch gum plywood skin.*

▲ *When gluing the apron skin in place, run a bead of glue into the apron retainer groove and spread it with a brush.*

▼ *Coat the outside edges of the apron formers and subrail with glue.*

▲ *Insert the edge of the apron skin in the retainer groove and bend it up and around the apron formers.*

▲ *Hold the upper edge of the apron skin against the subrail with a length of scrap wood and clamps until the glue sets.*

▲ *If there are high spots on the top edge of the apron skin, use a block plane to trim them flush with the top of the subrail.*

➢ *Glue the rounded corner blocks in place, to the apron formers and to each other.*

*Fill the steps of the corner blocks with auto body filler and let it set.*

*Sand the hardened body filler with garnet paper so that it forms a smooth rounded corner.*

*Slitting the billiard cloth as shown here will enable you to work around the pockets when covering the bed or rails. Note how the cloth is pulled around to the under edge of the table bed and stapled in place.*

*Using a sanding block, round the edges of the ball box with sandpaper.*

that is faired into the apron on each side. When this is done, smooth the surface with medium-grit (#120 to #150) garnet paper. Note: body filler sets rapidly, so don't mix more at one time than you can apply in about three minutes.

Cut the pieces for the ball box of ¾-inch pine and assemble it as shown in the drawing with glue and screws. Round the edges with sandpaper.

The bed of the table is made of ¾-inch particle board. Cut it to the dimensions

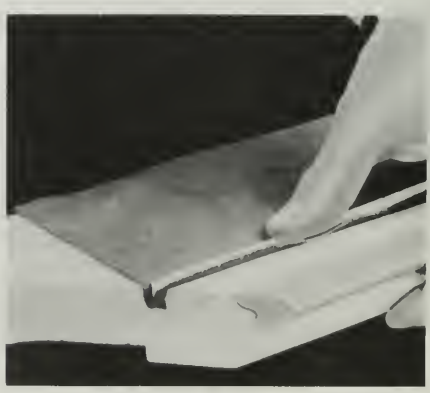
shown in the drawing and cover it with billiard cloth. Press the cloth first with a steam iron to remove the wrinkles and fold marks. The rest is easy. Do one long edge first, pulling the cloth around to the bottom side and stapling it in place. Make slits in the cloth to fit it around the pockets, as shown in the photograph. When you complete the long edge, do an end, then the other long edge and then the remaining end. Do not use a lot of tension, just enough to pull the cloth smooth.

Put the cloth covered bed aside temporarily, but remember to put it in place on the

*Use a dado head to cut the feather strip groove in each rail. Note that the filler strip has been glued in place and the two bevels of the inside edge have been cut.*

*Temporarily assemble the rail on the table to cut the pockets and the rounded outside corners. Undercut the pockets 8 degrees.*

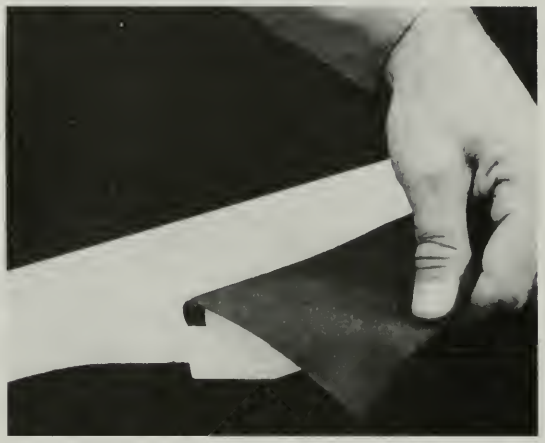
*When attaching the rubber cushion strip to the rail, let it extend slightly beyond the edge of each pocket.*



*When covering the rail, lay the cloth along the top of the rail, and place the feather strip on top of it over the feather strip groove. Press the strip into the groove so that it forces the cloth in with it.*

Trim excess cloth away with a sharp knife.

Fold the cloth back over the leather strip, around the cushion to the bottom side of rail.



Fold the billiard cloth at the pockets so the seam is on the bottom side and staple the cloth in place. Do not pull the cloth too tight. The rail here is upside down. Note how the cloth is stapled along the underside of the rail.

Cut the pocket bottoms to fit. The outside edges of the pocket bottoms are beveled to make sure the balls roll out and into the gulley. The side pocket bottoms are half round pieces, also with beveled inside edges. Each is covered with scrap billiard cloth.

**MATERIALS LIST**

| Quantity | Size and Description | Purpose |
|---|---|---|
| 2 | 1 1/4" 5 3/4"x50 3/16" pine | main rail ends |
| 2 | 1 1/4" 5 3/4"x88 3/16" pine | main rail sides |
| 6 | 3/16" 1 1/2"x34" pine | main rail filler strips |
| 6 | 1/4" 3/16"x33" pine | feather strips |
| 2 | 3/4" 2 5/8"x48 7/8" pine | sub rail ends |
| 2 | 3/4" 2 5/8"x81 1/2" pine | sub rail sides |
| 22 | 3/4" 2 5/8"x6 3/4" pine | apron formers |
| 2 | 1/2" 1 1/2"x43 1/2" pine | apron retainer ends |
| 2 | 1/2" 1 1/2"x81 1/2" pine | apron retainer sides |
| 2 | 1/8" 8 1/4"x43 1/2" gum plywood | apron ends |
| 2 | 1/8" 8 1/4"x81 1/2" gum plywood | apron sides |
| 1 | 1/2" 10"x77 1/4" fir plywood | tunnel bottom |
| 2 | 3/4" 6 3/4"x80" fir plywood | B bed supports |
| 2 | 3/4" 8"x86 3/4" fir plywood | C bed supports |
| 2 | 3/4" 8"x42" fir plywood | D bed supports |
| 2 | 3/4" 6 3/4"x80" fir plywood | center tunnel sides |
| 2 | 1/2" 3/4"x76" pine | tunnel bottom cleats |
| 2 | 3/4" 1"x34" pine | end bed support cleats |
| 4 | 3/4" 1"x32" pine | side bed support cleats |
| 1 | 3/4" 41 7/8"x79 7/8" particle board | bed |
| 4 | 3/4" 7"x31" pine | leg sides |
| 2 | 3/4" 5 1/2"x28 1/2" pine | upper leg stringers |
| 2 | 3/4" 2 3/8"x28 1/2" pine | lower leg stringers |
| 8 | 3/4" 3/4"x19 1/2" pine | leg cleats |
| 2 | 1/8" 20"x28 1/2" gum plywood | front leg skin |
| 2 | 1/8" 21"x28 1/2" gum plywood | rear leg skin |
| 8 | 3/4" 3 7/8"x16 1/8" fir plywood | gulley sides |
| 4 | 3/4" 3 5/8"x16 1/8" fir plywood | F gulley bottoms |
| 2 | 3/4" 5 3/4"x16 1/8" fir plywood | G gulley bottoms |
| 2 | 3/4" 6 1/4"x8" pine | ball box ends |
| 1 | 3/4" 2 3/4"x18" pine | ball box front |
| 1 | 3/4" 3 7/8"x18" pine | ball box rear |
| 1 | 3/4" 6 1/2"x16 1/2" pine | ball box bottom |
| 4 | 3/4" 4 5/8" diameter plywood | corner pocket bottoms |
| 2 | 3/4" 3"x5" plywood | side pocket bottoms |
| 32 | 3/4" 3"x3" pine | corner blocks |

**NOTE:** Also need rubber cement, glue, nails, screws, dowels, bed and cushion cloth, cushion rubber, pocket liners, leg levelers, body filler, sights and spots and score markers.

bed support structure before attaching the main rails permanently.

Cut the main rails to their basic shape. Miter the corners, but do not round the outside edges, bevel the inside edges, or cut the pockets.

Miter the corners, and check the fit on the table. Drill holes for two dowels at each corner as shown in the drawing—the easiest, most accurate way of doing this is with a dowel jig.

Use glue and nails to attach the filler strip to each rail section. Keep the nails away from the edge, because the filler strip and main rail will be beveled together as a unit.

Reassemble the rail sections on the table and clamp them into place. Lay out the pockets and the rounded corners and cut these with a saber saw. Set the saber saw to undercut the pockets 8 degrees. The rounded outside corners of the rails are not undercut.

Disassemble the railing and cut the groove for the feather strip on a table saw. Also make the two bevels for the inside edge at this time.

Apply the rubber cushion strip to the inside top beveled edge. Coat both the railing and strip with rubber cement and let the coatings dry. Press the two parts together firmly, allowing the strip of rubber to extend slightly beyond the railing at each pocket. When the strip is firmly in place, cut the ends of each piece of stripping flush with the pockets. Use a sharp knife dipped in water. The water on the blade acts as a lubricant and makes it easier to cut the rubber.

To cover a rail section with billiard cloth, place a long strip of cloth along the rail with one edge over the feather strip groove. Place the feather strip on the cloth over the groove and press it down so the cloth is forced into the groove.

Cut away the excess protruding from the groove on the inside edge and fold the remaining cloth back over the feather strip, over the rail and cushion and back underneath the rail where it is stapled in place. Fold the cloth at the corner and side pockets so the seam is toward the bottom and staple it on the underside of the rail. In addition, cut slits as necessary to work the cloth around the pockets as you did when covering the table bed. Trim away all excess cloth.

Put the table bed in place and attach the bed cleats to the apron sides and ends with screws and glue. When the glue is set, drive screws from the bottom through the cleats into the bed to hold it in place. Do not glue the bed or the rails in place because you may want to remove them some time later to recover the table.

With the bed in place, reassemble the rails on the table, gluing and doweling the mitered corners, and clamp it firmly in place. Drill, countersink and screw the rail sections to the subrail. Sights and spots cover the countersunk screw holes. Use a router to round the outside edges of the rails.

Cut the pocket bottoms as shown in the photograph, line them with scrap billiard cloth and stable them in place at the bottoms of the pocket liners. Staple the pocket liners to the apron or, if you have trouble getting a staple gun into the pocket, use tacks.

When finishing the table, with the wood finish of your choice, be sure to protect the felt with masking tape. Insert the spots and sights after the wood is finished.

*See also:* DOWELS; FINISHING, WOOD; GAME BOARDS; JIGS; ROUTER; SABER SAW; TABLE SAW; TOOL TECHNIQUES; WOODWORKING.

**WHERE TO FIND IT**

If your local dealer cannot supply the bed and cushion cloth, cushion rubber, pocket liners, leg levelers, body filler, sights and spots and score markers, for information write to The Armor Co., Box 290, Deer Park, N. Y. 11729.

*Bumper pool does not require the space of more familiar pocket billiards. The table bed is particle board and the legs are ready-made.*

# How to Build a Bumper Pool Table

## This mini-pool game is designed to fit in small spaces

THIS BUMPER POOL TABLE is ideal for use in cramped quarters, small apartments, game rooms, or even on porches and patios.

One great advantage bumper pool has over pocket billiards is its compact size. It measures only three feet by four feet. The cost is slight when you build it yourself.

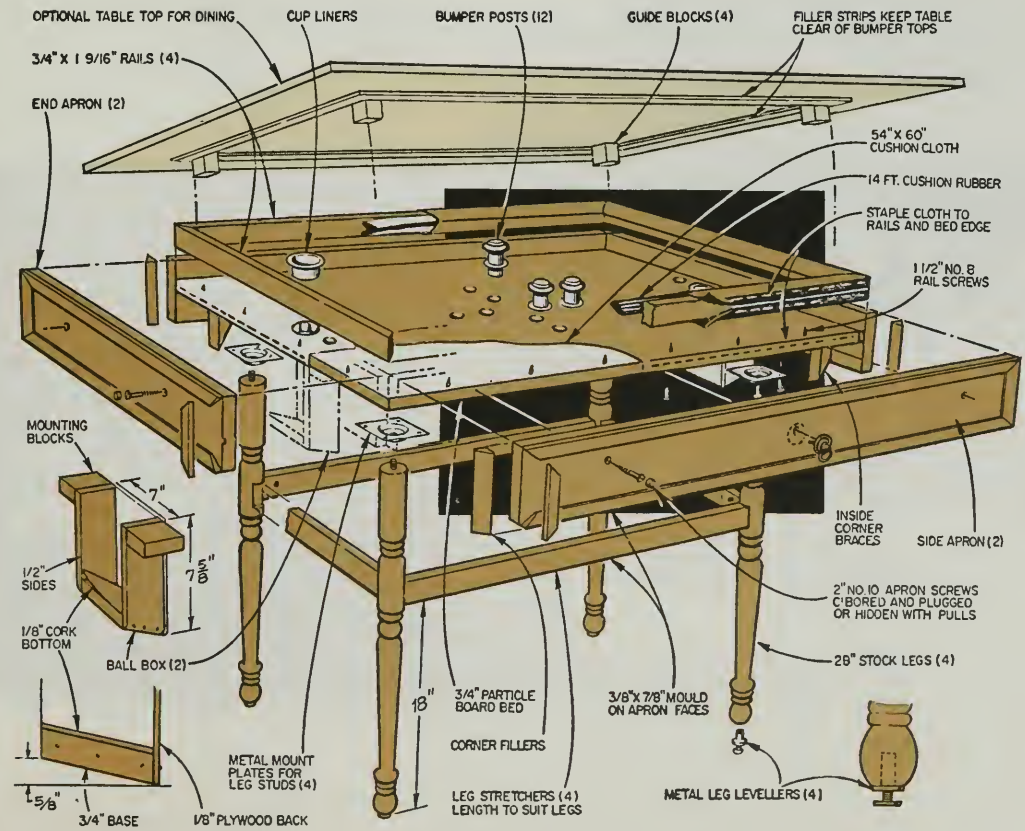
The table is also versatile. By placing a separate plywood top on the table, you immediately provide the hostess with a smooth surface expanse for dining. Use it also for a game table or for a cutting table when sewing.

This table has been designed with simplicity in mind. The legs are ready-made, and the other basic materials are readily available at your hardware store and lumber yard.

The table bed is made of particle board. Cut it to size, and mark the locations of cup and bumper post holes, as shown in the drawing. Post holes are 1⅜ inches in diameter; cup holes are 2⅝ inches in diameter. Use a speed bore bit to drill the smaller holes, and a hole saw or saber saw for the large ones. Saw a ⅛-inch slot in the edge of each post hole; this will help to keep the posts from rotating.

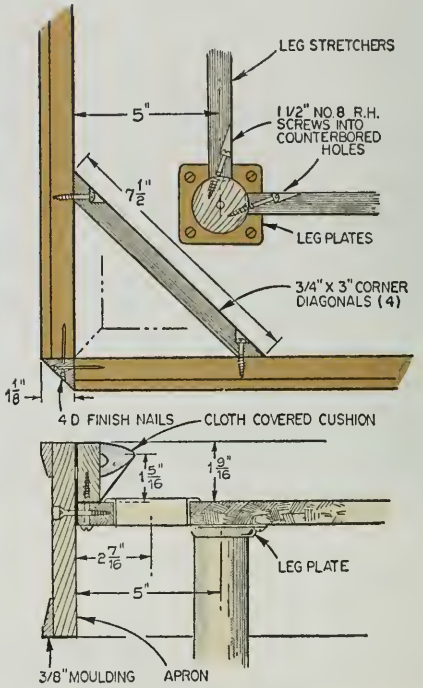
You can choose legs of any style, but they must be 28 inches long. Such legs are furnished with mounting plates, into which the legs screw. Install the four mounting plates on the bottom of the mounting bed. Distance from the sides should be about 5⅛ inches; distance from the ends should be about 5⅝ inches. Note: particle board is tough; drill pilot holes for the screws.

*A plywood top permits the bumper pool table to double as a dining table. Those who live in apartments might consider hinging the plywood top so it will store more compactly.*


OPTIONAL TABLE TOP FOR DINING
CUP LINERS
BUMPER POSTS (12)
GUIDE BLOCKS (4)
FILLER STRIPS KEEP TABLE CLEAR OF BUMPER TOPS
3/4" X 1 9/16" RAILS (4)
END APRON (2)
54" X 60" CUSHION CLOTH
14 FT. CUSHION RUBBER
STAPLE CLOTH TO RAILS AND BED EDGE
1 1/2" NO. 8 RAIL SCREWS
MOUNTING BLOCKS
7"
7 5/8"
1/2" SIDES
1/8" CORK BOTTOM
BALL BOX (2)
INSIDE CORNER BRACES
SIDE APRON (2)
2" NO. 10 APRON SCREWS C'BORED AND PLUGGED OR HIDDEN WITH PULLS
28" STOCK LEGS (4)
18"
3/4" PARTICLE BOARD BED
3/8" X 7/8" MOULD ON APRON FACES
CORNER FILLERS
METAL MOUNT PLATES FOR LEG STUDS (4)
LEG STRETCHERS (4) LENGTH TO SUIT LEGS
METAL LEG LEVELLERS (4)
5/8"
3/4" BASE
1/8" PLYWOOD BACK

## How to Build a Bumper Pool Table

▲ *Drill hole positions and cut holes for cups with saber saw or hole saw. Then legs are screwed into mounting plates.*



▲ *If cloth is wrinkled, press with steam iron on wrong side. Pull taut, staple ends first, then sides—with an inch between staples. Trim with sharp knife.*

➤ *Slit cloth with razor blade to accept posts and cup liners. For cup liners, stop slit 1/16-inch short. Tap the liners down flush.*

▲ *Staple cushion covering cloth to back of rails working from center out, as pictured. The cloth is cut 5 3/8-inch by needed length.*

▶ *At rail ends, pull cloth taut, form wedge with index finger, hold with one staple. Pull cloth from rear taut, staple, trim.*

▼ *Cushion rails are mitered, as shown in the photo, and given a coat of contact cement. Coat grooved back of cushion rubber also.*

Because any pool table must be absolutely level, it's necessary to install leveling jacks at the bottom of the legs. Drill a ½-inch diameter hole about 1 inch deep in each leg, then tap the jack socket into place with a mallet. The legs can be screwed into place at this time to bring the bed up to a convenient working height.

Now apply the cloth to the bed. If the cloth is wrinkled, press it on the wrong side, using a steam iron at a low heat setting. Staple the cloth along the bed edge at one end, then at the opposite end. Pull the fabric tight as you work. Next staple the cloth along one side; then the opposite side. Space staples about 1 inch apart, as shown in photo. Trim the cloth flush with the bottom of the bed.

At the location of each hole, slit the cloth so posts and cups can be inserted. Make four slits across the diameter of each hole; make them full width for the post holes, but stop them about $\frac{1}{16}$-inch from the edge of the cup holes. Now the bumper posts and cups can be tapped into place, the cups until they are just flush with the table bed top.

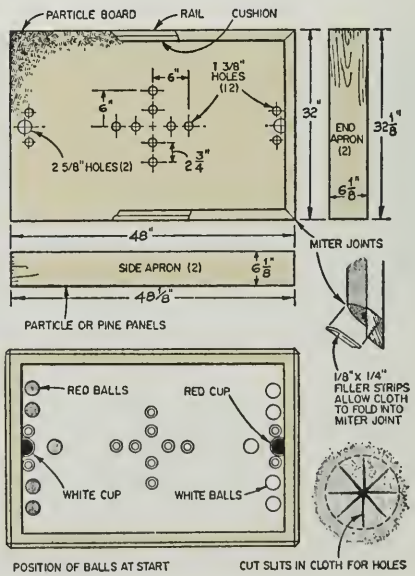
Side and end cushion rails are cut to length shown in drawing, and the corners mitered. Cut lengths of cushion rubber just slightly longer than the rails, and give them a coat of contact cement along their grooved backs. Also coat the face of each rail with the cement. Allow the cement to set according to the manufacturer's instructions, then carefully apply the cushion.

The cushion rubber must be flush with the top of the rail, with the shallow curve uppermost. Dip a sharp knife in water to lubricate the blade, and trim off excess cushion rubber flush with the mitered end of the rail. Make up four filler strips, each ⅛-inch thick, as shown in drawing. These are cemented to the end of each rail to form a lip under which the covering cloth will be stapled.

Cut cloth in strips 5⅜ inches wide by the required length for each rail, and staple it in place along the back as illustrated. At each end, pull cloth tight along the front, use your index finger to form a wedge, and tack the folded cloth in place with one staple. Cloth from the rear is then pulled taut, and another staple is applied; now trim away excess cloth. When the rails are butted together, the staples and cloth folds will be under the lips formed by the filler strips.

Install the rails along the edges of the bed, using round head screws from the underside of the bed. Be sure to drill holes through the particle board, and pilot holes in the rails. A little soap on the screws will make them a lot easier to turn.

Now you can add the finishing touches. Cut the side and end aprons to size, and install them as shown in drawing. Note that the screw holes can be covered with decorative molding, or the heads can be countersunk more deeply, and screwhole plugs glued in over them. Space the screws as shown and install corner blocks and corner braces.



**MATERIALS LIST**

| Quantity | Size and Description | Purpose |
|---|---|---|
| 1 | 3/4" 32"x48" particle board | bed |
| 2 | 3/4" 6⅛"x48⅛" pine | side aprons |
| 2 | 3/4" 6⅛"x32⅛" pine | end aprons |
| 2 | 3/4" 1¾6"x47¹¹⁄16" pine | side rails |
| 2 | 3/4" 1¾6"x31¹¹⁄16" pine | end rails |
| 2 | 3/4" 4"x6 1/2" pine | ball box bottom |
| 4 | 3/4" 1 1/2"x3 3/4" pine | ball box support tabs |
| 4 | 3/4" 3"x7 1/4" pine | corner braces |
| 4 | 3/4" 2"x required length pine | leg stretchers |
| 4 | 1/2" 3 3/4"x7⅝" pine | ball box sides |
| 2 | ⅛" 7⅝"x7 1/2" plywood | ball box back |
| | ⅜" ⅞"x36' pine molding | |
| as needed | #8 1 1/2" round head wood screws | |
| as needed | #8 1 1/2" flat head wood screws | |
| as needed | #8 1 1/4" flat head wood screws | |
| as needed | #10 2" flat head wood screws | |
| 4 | 28" ready-made legs of your choice | |

**NOTE:** Also need cushion rubber, bed and cushion cloth, bumper posts, cup liners, leg levelers, balls, cues and finish materials of your choice.

Cut the leg stretchers to the required length, and screw them in place. Note that the screws must be angled into the legs; pilot holes are a must to avoid splitting the legs. These stretchers not only give added stability to the table, they prevent the legs from turning in their sockets.

Finally, make up the ball box, using the dimensions shown. Note that the bottom is angled up toward the front to keep the balls from rolling right out when they drop into the box. Line the bottom of the box with cork.

Paint or varnish the table as desired; your local paint dealer can help you choose the right materials to provide the finish you want. This completes the basic bumper pool table.

To add to its utility, you can make up a slip-on covering board—a table top—that will fit snugly over the pool table. It can be almost any shape, just don't make it so large that stability problems will develop. Shown is a table top upside down: note that four blocks are attached to keep the top in place by fitting snuggly into the corners of the cushion rails. The filler strips between the blocks raise the top slightly so that it does not rest on the bumper posts, which are a little higher than the rails.

*Original design by Steve Ellingson.*

*See also:* GAME BOARDS.

**WHERE TO FIND IT**

If your local dealer cannot supply the cushion rubber, bed and cushion cloth, bumper posts, cup liners, leg levelers, balls and cues, write for information to The Armor Co., Box 290, Deer Park, N. Y. 11729.

# Understanding Your Car's Power Steering

**You can make some of the repairs yourself. The others must be done by a mechanic, but if you know your car's steering system, you will get a cheaper, more reliable job**

UNDERSTANDING YOUR POWER steering is easy and important when pinpointing trouble. Fixing it though, may be another matter. You can easily make some repairs, but if the trouble is in the power steering unit itself, most repairs are best left to an expert who knows what he is doing and has the special tools and gauges. However, if you watch the repair being done and know your power steering, you should get a more careful and less expensive job.

All power steering systems have these three components: 1) a pump which supplies oil under pressure to provide the power and 2) a control valve assembly to meter the amount of fluid delivered to 3) the cylinder and piston assembly that does the work.

Systems differ in design and location of control valves and cylinder and piston assemblies. The two basic categories are those where the power is applied to the steering gear and those where it is applied to the linkage. Gear-type units are built into the steering gear box with opposed power pistons working on a crank attached to the pitman arm shaft. Some use a single power piston working on the pitman arm shaft through a power rack. Both of these gear-type units have the shaft from the steering wheel passing through the control valve assembly.

Linkage-type power steering mounts the cylinder and piston assembly between one of the steering rods and the vehicle chassis or frame.

Here is what happens when you turn the wheel on a power steering equipped car. The pump, belt driven by the engine, draws hydraulic fluid from a reservoir and sends it out under pressure. Inside the pump, flow-control and pressure relief valves govern the amount of pressure in the system. The harder you turn the steering wheel, the more hydraulic pressure is applied to help you turn it.

Two hydraulic lines connect the pump to the control valve. One is a flow line, the other a return line, or both may be flow lines depending on front wheel position. The control valve, like a traffic cop, directs fluid under pressure to the power cylinder.

With the wheels straight ahead, a centering spring holds the control valve spool in the neutral position. Fluid from the pump bypasses the valve, enters the power cylinder and returns to the reservoir. Pressure is equal on both sides of the piston.

When you turn left, twisting the steering wheel makes the valve spool move to the right, overcoming the control valve centering spring. Hydraulic fluid, under pressure from the pump, flows through the line to

**power supply, hobbyist's:** see workbench

the right side of the power cylinder. Fluid on the left side of the cylinder is forced back through the return line as the piston moves to the left to assist your turn. On a right turn the process is reversed.

*Spotting power steering troubles.* Leaking fluid, hard steering, binding or poor recovery, excessive free play, noise, steering chatter, rattles and complete loss of power assist are all trouble symptoms. Fluid loss and hard steering are the most common.

When you notice one of these symptoms, there is usually no need to replace any of the complete power steering assemblies, let alone the entire system. Never let yourself be talked into such replacement until you are absolutely certain you need it.

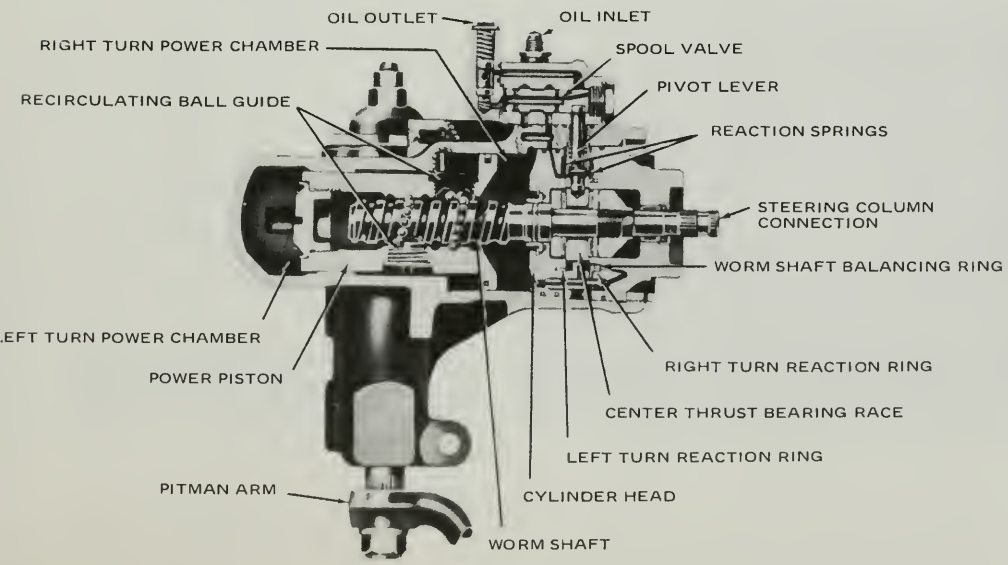
Fluid leaks show up as a few drops or even a puddle on the garage floor. Ignore this warning and you're in for hard steering and the expense of replacing fluid.

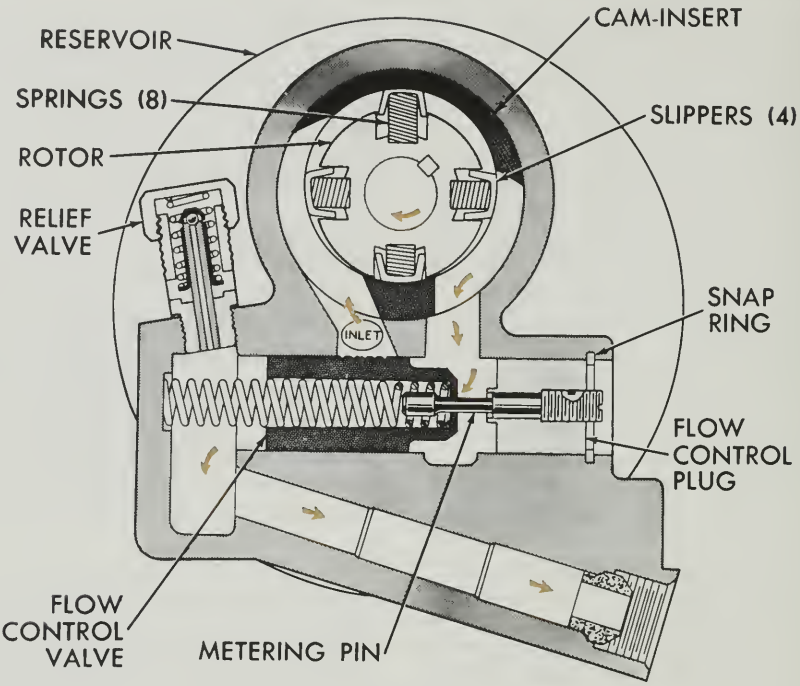
To find the leak, get under the car. If you can get it up on a hoist, it is much easier. Clean off the pump, control valve, power cylinder, and all the flexible lines and fittings. Drain the pump reservoir, catching the fluid in a clean container. Add ½-teaspoon of premixed red oil-soluble aniline dye to each pint of fluid. Some auto supply stores carry this dye. Then refill the pump reservoir with dyed fluid. Start the engine and turn the steering wheel from one side stop to the other at least ten times to circulate the dye through the system. Get an assistant to turn the wheel from one stop to the other and hold it at each stop for 10-15 seconds while you look for leaks in the system.

If a tubing fitting leaks, try tightening it. Use special tubing fitting wrench in preference to an open-end wrench. (If you don't have a tubing wrench, go ahead and use an open-end. Just be careful.) If this does not help, replace it with a new fitting of the same size and type. If the leak is in one of the fluid lines, replace the line.

Leaks can occur at six places on the power steering pump and reservoir unit: cover joint, cover center stud, reservoir

*Sectional view of a Dodge power steering gear which consists of a gear housing containing a gear shaft with a sector gear, a power piston with gear teeth milled into the side of the piston (which is in constant mesh with the sector gear), and a worm shaft connecting the steering wheel to the power piston (through a U-joint). The worm shaft is "geared" to the piston by recirculating balls. The steering valve, a spool type, is mounted on top of the steering gear and directs flow of fluid into the system.*






*This is a typical power steering pump, designed to deliver most of its pressure at low speeds for easier parking. At low speeds, the flow control valve is so positioned that additional oil flows through the valve orifice to the power steering gear. At higher pump speeds, the increased oil flow moves the flow control valve against the spring pressure, diverting much of it back into the pump inlet. At the same time, the metering pin reduces oil flow to the power steering gear.*

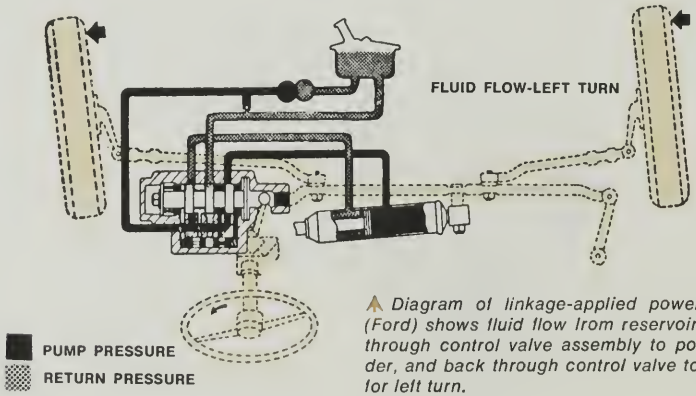



*Diagram of linkage-applied power steering (Ford) shows fluid flow from reservoir to pump, through control valve assembly to power cylinder, and back through control valve to reservoir for left turn.*

➤ *Dipstick permits easy checking of power steering pump reservoir.*

body to pump housing joint, between pump body valves, carrier shaft, and relief valve retainer. Fix any of these leaks by removing the pump and reservoir units from the car and replacing the leaking gasket or seal. Individual gaskets and rebuild kits are available from auto supply stores and mail order houses.

Bleed air out of the system whenever a line has been disconnected, a component replaced, or the reservoir has been emptied to change the fluid. Make sure the reservoir is full. Jack up the car so the front wheels clear the ground. With the transmission in neutral, the rear wheels blocked, and the engine running, depress the accelerator until the engine races at a speed equal to about 35 mph. Slowly turn the steering wheel all the way left, then all the way right. Lower the car to the ground and again turn the wheels slowly all the way left, then right. Recheck the reservoir, add fluid if needed and the job is done.

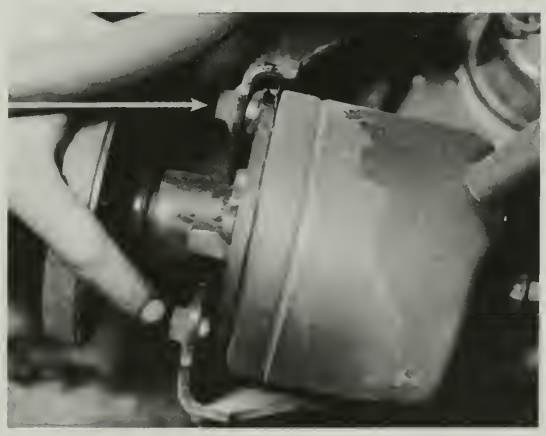
Hard steering can be caused by a slipping power steering drive belt. All belts squeal to some extent when you have the steering wheel cranked all the way during a parking maneuver, but the belt should not squeal during normal low-speed or high-speed driving. If it does, adjustment or replacement is indicated.

Two bolts hold the typical power steering pump. Slacken both and tension the pump with a pry bar.

Any further service on power steering requires special test gauges, and should be left to the professional mechanic. P.W.

*See also:* BALL JOINTS; BEARINGS; DISC BRAKES; DRUM BRAKE SERVICE; HYDRAULICS.

▲ *Although tubing wrench is best, open-end wrench can be used on power steering hoses.*



➤ *Two bolts hold the typical power steering pump. Slacken both for pump belt adjustment. (Finger points to bolt on elongated hole adjusting brace; arrow points to the other bolt.)*

# All about Power Tools

**Power tools make long chores short and hard work easy. Here's a rundown on which types you'll probably need and how to pick them out**

POWER TOOLS make home maintenance chores easier and less tiring; they also broaden the range and quality of the work. A few inexpensive portable electric tools will do most home jobs quickly, neatly, and almost without effort. Even more important, these electric tools greatly expand the homeowner's capability to handle more complex repairs for a considerable saving in expenses, and open the way to various home improvement projects that mean so much for family comfort and convenience.

Portable power tools are among the best investments you can make. The five most widely owned tools—the electric drill, saber (jig) saw, sander, circular saw, and router —will equip you for nearly all the jobs around the house that you are likely to encounter. The cost of the tools is returned many times over by the savings in expense for outside services that you will be able to do on your own, quickly and easily.

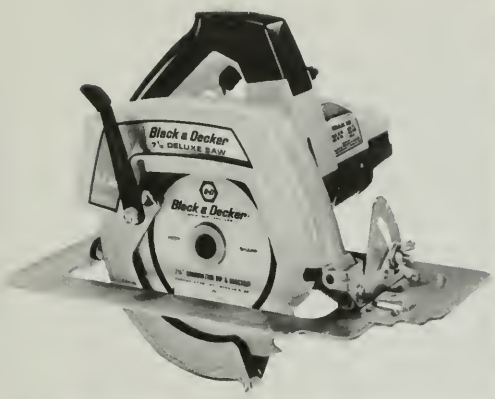
Some persons shy away from power tools because of uncertainty about their ability to handle them, although they do not hesitate to drive a car, which requires extensive experience, constant alertness, instant response, and the exercise of every faculty to deal with the ever-changing traffic scene. Any power tool, by contrast, is simple and direct in action. There is no external interference. It is reasonable to expect that anyone who can drive a car can, after just a little experience, handle any portable power tool. There are many rules for safe driving; there are just a few easily learned rules for safe use of electrical appliances, including most portable power tools.

A drill and sander, the simplest power tools, require no training. Careful reading of the instruction manual supplied with the tools is sufficient for operating a saber saw and router. Some experience, however, and greater caution are required for accurate cutting with a circular saw, but the efficient performance of this tool is well worth the attention required. The usual safety precautions which apply to all electrical accessories must be observed, of course.

Most tools are equipped with a three-wire electric cord, which includes a grounding wire connected to the shell of the tool and a special grounding prong on the plug, for shock protection. This plug is intended to be used in a grounded receptacle, so that any short circuit within the tool itself will be grounded through the circuit and thus protect the user.

If your house has old-fashioned two-prong receptacles, this is the time to switch over to the safety type, which cost less than $1. each. With the circuit current shut off by pulling the fuse, transfer the wires from the original receptacle to the new one—but this time, watch the polarity. Connect the black wire to the brass-colored terminal screw, the white wire to the silver screw, tightening the terminal screws firmly.

**pram:** see training boat
**pram, lightweight:** see runabouts
**prefabricated chimney:** see fireplace
**pre-glued floor tile:** see floors, tiling
**pressure test:** see fuel pump



*These five power tools—drill, saber saw, sander, circular saw and router—form a complete homeowner's kit. If you don't want to get them all at once, start with a drill and saber saw. Next buy a sander and finally a circular saw and router. They will handle most jobs.*

If your electrical wiring has no ground continuity (by armored BX cable, metal thin wall conduit or a third grounding wire in the cable), it is necessary to establish such a ground by connecting a separate wire to a water pipe. Any extension cord used with a tool must also be of the three-wire type with suitable connector devices to assure continuity of the ground connection through the extension to the wall receptacle.

A more recent method of tool construction assures electrical safety by double insulation rather than a grounding plug. These tools, which comply with the standards of the Power Tool Institute, are made with a non-conductive, high-impact plastic case so that the user is fully insulated from an electrical short within the tool. Ordinary precautions should be observed, nevertheless, for using any electrical device in damp areas, including the required wire gauge and limitation on length of extension cord.

However well you develop skill and confidence in using these tools, never cease to maintain the respect that they deserve. These are "friendly" tools that will serve you well, but like all electric devices, they are powerful and can be dangerous if misused. Make sure everything is in order each time before throwing the switch; always pull the plug before making any adjustment on the tool.

One question that soon pops up with the new homeowner: which tools or tool to buy first? Also, when the displays are examined at the local stores, there's the inevitable confusion about making a selection because of the wide price ranges and varied features of the different models. You don't want to be cheated by a sloppy tool, yet there's doubt that you really need those rugged tools that look as if they were made for steel construction jobs. You're right—the idea that you get "only what you pay for" does not completely apply to power tools. We will try here to present sufficient data to help you make intelligent, practical selections.

The first problem is what type of tools you need. The recommended order of purchase is, first, the drill, then the saber saw, next the orbital sander, and finally the circular saw and the router. There are a few other useful tools that might best serve your special needs: the belt sander, used for heavy sanding such as smoothing rough-cut boards; the disk sander, mostly for metal such as auto fenders; the hand-held grinder that is important mostly to the hobby model maker. A workshop vacuum cleaner, with the extra large dirt collection tank, also is a portable tool and you may decide it rates higher priority as a valuable addition that controls sawdust and other workshop debris and is useful for many other purposes, including lawn cleanup.

Each of these tools can do its particular job better than any of the others. Some combinations are possible that extend the versatility of the tools: a disk sanding plate can be used with the drill; an orbital sanding accessory powered by the router motor, even a jig saw attachment or planer for either drill or router—in each case, the main tool serves as the motor for the accessory. In any event, you save little by using these accessory attachments; it's better to have an individual tool for each purpose.

The recommended buying sequence can, of course, be altered to meet current needs; perhaps you require a sander right away, and are not likely to use the circular saw for some time. Regardless of any work that you plan to do, the drill and saber saw are so basic that they should be your first purchases. When you have them handy, you're more apt to tackle jobs that otherwise would be put off or neglected.

A question that relates to all power tools is the relative power required. Do you need a "heavy-duty" model in each instance, and how far do you go up the price ladder?

Avoid underpowered "price leader" tools that are likely to burn out at the first major test. Also avoid those massive, extra-heavy models that are designed for constant professional use—they not only cost much more, but are too bulky and unwieldy for average home purposes. Moderation is the general rule. Buy the medium range in all cases, not the light-weight competitive job, or the builders' and contractors' models.

Get the tool with all modern features (variable-speed and reversible motor are both highly desirable) and extra safety provisions. Another important guide—stick to the highly regarded brands for assurance of quality, a fair price and readily available parts and service.

*Electric drills.* How do you select the right drill to buy? The choice will depend, of course, largely on the kind of work you expect to do. But that is only a partial guide—the fact is that you will, sooner or later, need to do some drilling that is more difficult than you now anticipate, perhaps on your car fender to install a burglar alarm switch, or for a new catch on a steel window frame.

An under-powered motor may falter at such a tough assignment, or its motor burn out and the drill become worthless; it just doesn't pay to repair a low-priced drill. So spending a bit more can be the cheapest in the long run, since a drill of adequate power serves you for more purposes and can last indefinitely, returning its cost many times over without costing a cent for repairs. Replacement of the motor brushes is a different routine matter, since universal motors do tend to wear out their brushes. Most standard makes have externally accessible brushes, for easy replacement.

Also, be sure to get a drill of current design with a double-insulated housing and a reversible, variable-speed motor.

▲ *The most useful household power tool is the electric drill. Look for one with a double-insulated housing and a reversible, variable-speed motor.*

▼ *Drill with special bit is used to bore holes in masonry. Variety of bits and attachments give the drill its versatility.*

**RANGE OF APPLIANCE MOTOR POWER**

| Horsepower | Amperes |
|---|---|
| 1/7 | 2.0 |
| 1/6 | 2.2 to 2.5 |
| 1/5 | 2.5 to 2.7 |
| 1/4 | 2.5 to 2.7 |
| 1/3 | 3.6 |

Drills are classified basically two ways: by chuck capacity and motor power. The ¼-inch drill will receive bits with a shank of ¼-inch diameter, but holes larger than ¼-inch and up to 1-inch and larger may be drilled with spade bits, expansive bits, and hole saws having shanks of ¼-inch that will fit the drill, thus this capacity will be adequate for most homeowners. However, the ⅜-inch chuck provides the additional capacity that can be very important on occasion, and the ⅜-inch drill usually has a stronger motor, so that the slight additional cost is warranted.

Drills can be separated into three categories: light-duty, medium-duty and heavy-duty. The light-duty drills of standard manufacturers usually are of good quality, but beware of the "price leader" bargain that does not specify the horsepower, or has ampere draw of less than 2.0 amps.

A suitable drill for general purposes would have a ¼-inch chuck, a ⅙-hp. or 2.2-amp motor. The homeowner who does extensive maintenance and workshop projects would do better with a ⅜-inch drill having a ⅕- or ¼-hp., 2.5-amp. motor, with variable-speed.

Another determination for your selection is the feel of the tool. Heft the various models to see whether they feel comfortable. A drill that seems extra heavy or clumsy may make for difficult work, so your final choice—other things being equal—should be the drill that feels right to you.

The power of universal appliance motors is stated in either amperes of current draw, or fractional horsepower, or both.

Variable speed may be controlled by trigger squeeze in some models, selector switches in others. Some combine both features with a three-speed trigger lock that maintains the selected speed continuously. Soft metals are drilled at the highest speed, while concrete and other masonry are drilled with carbide bits at the slowest speed.

Free-running motor speed, which means without load, ranges from about 2,500 rpm downward to as little as 500 rpm, which is achieved by a system of gears. Portable drills have universal motors which gather speed while running free, but slow down under load. The poorest quality drills have the highest speed. The variable-speed feature, found on the better drills, serves to prevent the motor from "running wild" and provides optimum torque for the job to be done.

Certain accessories extend the usefulness of the drill; these include sanding disks, buffing wheels, grinding wheels, and paint mixers. Some other accessories offered for use with the drill are of doubtful value or practicality. One such is the circular saw attachment, which, when fitted to the drill, is bulky and unbalanced. The resulting tool is difficult to use with any accuracy and may burn out the motor if the blade binds. A separate circular saw, even the smallest, would be more practical, though that of course involves additional outlay.

A helpful recent addition is the drill guide, which holds the bit steady while drilling. The guide eliminates the out-of-round holes that ordinarily result when the drill is not held steadily. A container at the bottom of the guide holds an assortment of drill bits.

The variable-speed drill becomes a power screwdriver with the addition of a set of special screwdriver bits, including two sizes for slotted screws and two Phillips drivers, to end a tiresome workshop task when many screws must be driven. Also, fitting for square shank socket drive turns the drill into a power socket wrench, permitting rapid assembly of metal cases and other parts. Drills with a reversible motor can be used to turn out screws and nuts, while tapping dies extend the drill's versatility even further.

If you already have a satisfactory drill,

but one without the desirable variable-speed feature, you can obtain a speed reducer. This attachment increases drill torque up to 700 percent, and is reversible. The speed reducer can also be used on other portable appliances.

*Saber Saw.* A saber saw can handle an almost unlimited range of sawing jobs. It's handy and easy to use. Need to cut off a part of a board? Just pencil the line and let the blade zip along, making the cut in seconds with no effort on your part. Want to cut a circle or other shape? The saber saw does it neatly and quickly. Similarly, the little reciprocating action blade will trim down excess on a cabinet so that it can be fitted into its place, bites its way through hard plastic sheeting and metal bars. You can make inside cutouts in plywood or wallboard paneling to clear electrical outlets without even drilling a hole for the blade, which starts its own with a plunge cut. In wood, the saw cuts either cross grain or with the grain and nibbles its way through the hardest knots.

The saber saw is perhaps the safest of the power saws, and the easiest to use. The rigid, narrow blade is partially contained within the baseplate area, extending about

▲ *Saber saw is fast, maneuverable and easy to use. A wide range of blades enables it to cut materials ranging from metal to plywood.*

▲ *Just move saber saw blade along guideline for easy, fairly accurate cutting.*

an inch below the plate. When using the saw, keep one hand on the saw handle, with a finger on the switch and the other hand resting on the work and holding it steady. Usually, the work is supported on the work bench, across sawhorses, or other support. But support is not essential as with other saws; a long board may be held by one hand while an end is being cut. Short stock should be secured in a clamp or vise. Just set the blade at the edge of the cutting line, press the switch to start, then gently ease the blade along. To cut curves, simply follow along the line. When you come to a sharp corner, back the blade once or twice to widen the kerf enough for the blade to turn easily—forcing the blade into too sharp a turn can snap it.

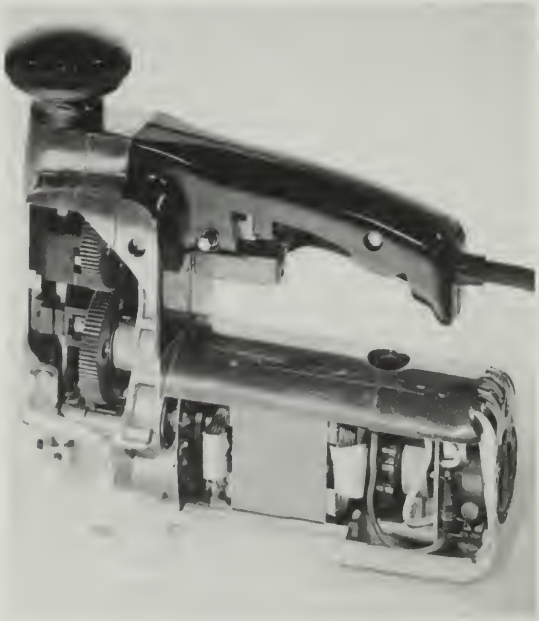
Thin sheet metals of all kinds are easily cut with a hacksaw type of high-speed steel blade, but to avoid chattering that can result in inaccurate cutting, back up the metal with a piece of scrap wood. Cutting speed depends largely on the kind of metal and its thickness. Do not exceed the pres-

sure that is in keeping with the chipping action of the blade.

More than a dozen types of blades are available for cutting different materials, and in various situations. For wood, teeth settings on blades vary from coarse, medium and heavy duty to smooth, including extremely narrow blades for close radius curves.

Some of these blades are Teflon-coated for minimum friction. Blades of high-speed steel are used for metal cutting.

While all other saber blades cut on the upstroke, a high-carbon taper-ground blade for Formica and other plastic laminate sheeting has inverted teeth to permit top cutting of the plastic without chipping, a distinct advantage when making cutouts after lamination, such as for a kitchen counter.



*Cutaway view of variable-speed saber saw shows, from right, silcon-controlled rectifier, motor, counterbalanced speed-reducing drive.*

Other blades include carbide-toothed scroll cutters for use on Masonite and plaster, and a specially shaped flush cutting blade that permits cutting right up to a blocking wall, as when trimming floorboards. There are also "toothless" blades in which the cutting edge is coated with fine abrasive particles; these are used mainly on items such as ceramic tile, slate, and marble in which breakage would otherwise be a problem.

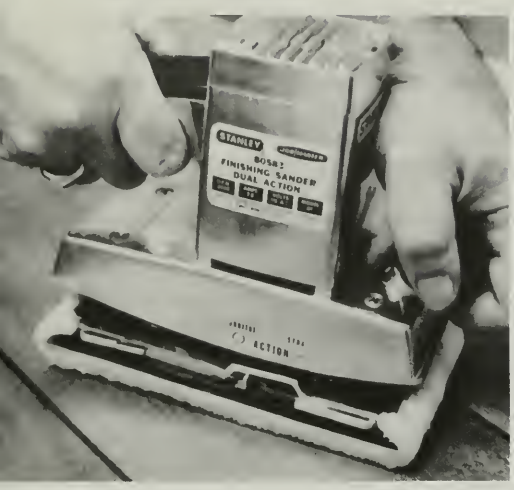
Like every other tool, the saber saw has limitations. It does not completely take the place of a jig saw or circular cutoff saw. While an adjustable gauge helps guide the blade for straight cuts, this will not assure sufficient accuracy for jointing. Scroll cutting can be done to a close radius, but not as closely as the thinner-blade jig saw or coping saw can do it.

In selecting your saw, the two most important quality factors to consider are the motor power, and length of blade stroke. The lower priced tools have ½-inch stroke; the better saws have ¾-inch and even 1-inch stroke. Motors range from ⅙-hp. up to ½-hp. The longer stroke and more powerful motor will, of course, produce quicker and smoother cutting.

Other features that are worth the additional cost are multiple-speed or variable-speed control, as selection of the right speed for each kind of work results in easier cutting and less wear on the blades; a sawdust blower, which helps keep the guide line visible; minimum vibration to make the saw operation quieter and more comfortable; a small headlight for better visibility when working in darkened area and adjustable edge guides.

Blade breakage, resulting from improper handling, can represent needless expense. A little experience will enable the new user to determine the amount of pressure and radius of turn that will avoid snapping the blades.

*Sanders.* The ultimate quality of many




*This pad sander provides either orbital or straight back-and-forth motion at the flip of a switch. Spring-loaded retainers on pad permit rapid change of sandpaper.*

*Sanding between coats provides a sleek finish for furniture. Change to a finer grit at each sanding stage.*

projects depends on their finish. That's where the orbital pad sander gets a starring role, producing a smooth surface on lumber, plywood, composition board and other material as a preparation for staining, varnishing or enameling. You will find frequent uses for the tool also in waxing and buffing furniture and sanding between coats of shellac and varnish to eliminate air bubbles and dust for a smooth final finish.

There are several other types of sanders, including the disk, belt, drum and plate. The disk, or rotary sander, is used with sandpaper or coarse wire cup brushes to grind and smooth metal, such as auto fenders and similar irregularly shaped surfaces. A lambs wool bonnet placed over the rubber disk is excellent for buffing the car.

The belt sander is used for fast wood removal to smooth boards and trim them down to precise thickness needed for some forms of jointing. The belt sander will be particularly useful to boatbuilders for dressing rough-sawn hardwood stock. It is also useful in conjunction with rotary floor sanders to cover the room perimeter, because it can sand close to the wall. The average homeowner, however, will not have sufficient use for the rather expensive belt sander to warrant the purchase. Belt sanders can be rented when needed.

The drum sander is used for curved and other irregularly-shaped edges. A paper sleeve or cone, from 1 to 4 inches in diameter, slips onto a rubber retainer which has a ¼-inch shank to fit the chuck of a drill press or portable electric drill. As the sanding drum rotates, the work is moved against it.

The plate sander is a large flat plate to which a sandpaper disk is attached with rubber cement and is used mostly to trim angle-cut stock for perfect miter joints. The plate sander is used mainly in stationary tools, such as a bench saw, but may be

adapted to a drill that is fastened down with metal straps.

The pad sander, the type most useful to the homeowner or apartment resident, does its work by either straight-line back-and-forth (oscellating) motion, or by orbital (circular) action. Dual sanders do both. They can be switched from forward-and-back to orbital when desired. Mostly, the orbital motion, together with movement of the sander along the direction of the grain, will produce the quickest and most satisfactory result, without visible sanding marks, when a fine grit paper is used. The straight-line motion, however, may be helpful with certain open-grain woods, such as oak.

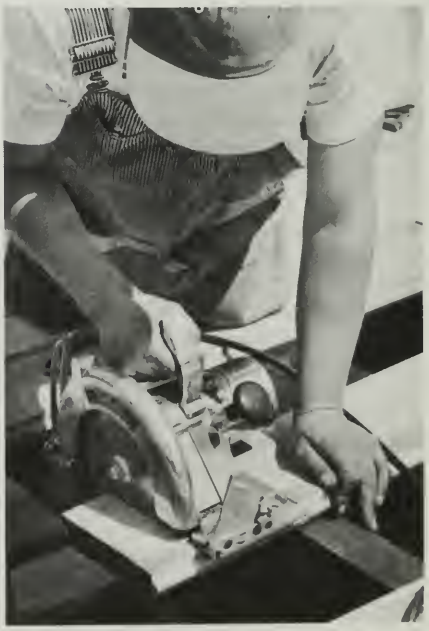
Details to look for when selecting a sander are: adequate motor power; frequency of orbital motion; light weight, which can be important when you work on vertical surfaces; adequate pad size, a dust collector bag, and a convenient arrangement for changing the sanding paper.

In the orbital sander, the circular orbit of the pad is only about ⅛-inch in diameter. Ample motor power assures faster cutting without overheating, and longer service. The average good quality orbital sander has ⅕- or ¼-hp. motor, delivering about 4,000 orbits per minute. The smaller and lighter weight ⅙-hp. model is usually adequate for light finishing and polishing duty. At much lower cost is the magnetic vibrator sander that turns out about 15,000 strokes per minute for very smooth finishes, but these models are much noisier than the motor-driven types.

When used on horizontal surfaces, the weight of the orbital pad sander will provide sufficient pressure. Just glide it along, keeping it in line with the grain as much as possible. Avoid pressing down on the tool because that may result in "spotty" segments that will become aggravatingly obvious after the finish is applied. When doing vertical work, hold the tool with both hands, gripping the front with the extra handle to maintain uniform contact with the entire surface.

Pad size varies somewhat for the different models, but may not be particularly significant for your purposes. The average is 3⅝ x 7¼ inches. The more expensive sanders may have a pad as large as 4½ x 9 inches. Precut sanding sheets are available in half a dozen grits of aluminum oxide abrasive, from very coarse to extra fine, ready for use.

*Cutoff saw.* Finishing a basement recreation room? Enclosing a screened porch? Building a redwood deck in your backyard? Adding a bedroom in the attic? A portable circular saw will be the chief power tool for these projects. Lay out a half dozen 2 x 4s, side by side, and the circular saw will zip through the lot in less than a minute,



*Portable circular saw quickly crosscuts or rips boards cleanly and accurately.*

cutting all six to the required size. Paneling goes up rapidly when the saw is used for the necessary trimming.

But the saw is used not only on lumber and plywood; it makes short work of cutting down heavy doors to clear new carpeting; cuts brick and plaster for such jobs as inserting a through-the-wall air conditioner, and will square slate flagstone for house walks.

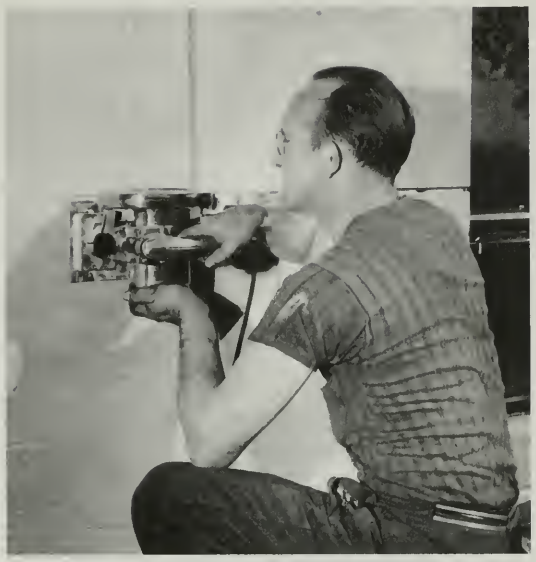
New owners of a circular saw should devote a little time to getting acquainted with the saw mechanism, studying the underslung blade guard, the control switch, and the blade tilt lock. The retractable guard swings away as the blade enters the work, snaps back by spring action to cover the blade again when the cut is completed. The base plate can be raised or lowered, allowing greater or lesser projection of the blade, and is locked in the selected position by a knob on the motor housing.

Bevel cuts are made by tilting the saw on its baseplate at the desired angle as shown by a protractor gauge. There are various types of ripping guides and jigs that permit fairly straight cuts, but most work with the saw is done freehand with penciled guide lines.

*Rules for safe and accurate sawing.* Keep blades sharp, use the right type for the job. Provide adequate supports for the work, securing short boards with clamps or in a vise; set the blade projection at just ¼-inch more than the thickness of your material. The saw rests on the main part of the work, never on the cutoff portion.

When cutting, hold the saw with both hands, the right hand on the handle with a finger on the trigger switch, the left hand on the front knob, guiding the saw. Let the cutoff piece fall, don't reach for it until the blade has stopped turning.

To start the cut, rest the saw plate on the work, pull the switch trigger, let the motor reach full speed, then ease blade into the work on the cutting line. Blade guard should retract, allowing the blade to move forward. Maintaining motor power, feed the blade ahead along the line, at a steady, uniform speed, as quickly as the cutting goes, but not forcing.



▲ *Power saw's relatively light weight makes it easy to use right on a wall. Use special resin wheel to make cutouts in brick or plaster or other masonry.*

Be careful to stay on a straight line; otherwise the blade will be slightly twisted and bind, possibly causing kickback, in which the saw flips over out of your grasp. Various devices have been designed to prevent kickback, one of which is a "slip clutch" that is intended to allow the motor to spin freely when the blade becomes jammed. The clutch action depends on precise adjustment of the blade tension, hence is not entirely reliable. Another device is a splitter knife located just behind the blade to keep the kerf open. This must always be in perfect alignment with the blade.

Saw blades range in diameter from 6½ to 7½ inches. Depth of cut depends on the blade diameter. 6½ inches is the smallest size able to make a straight cut through 2-inch stock, but only when the saw is not tilted for bevel cutting. The largest saws have more powerful motors and a wider range, but may be heavier than you would want to handle, so unless you will be using thick beams and do a lot of masonry cutting, the medium size 7- or 7¼-inch blade is preferred and will clear a 2-inch thickness at 90 degrees. (Remember that your lumber is not the full thickness of its nominal size.) However, the extra depth margin plus more powerful motor of the 7¼-inch blade are desirable.

Double-insulation on some saws assures safety against shock, eliminating the bother of attaching a grounding cord. Another valuable safety feature is the electronic brake that stops the blade spin instantly when the saw is switched off.

Blades for portable saws are made of tough saw steel, specially tempered. The blade used most often is the combination type, suitable for most wood cutting jobs and producing a smooth edge that permits jointing without further sanding. Use it for ripping, cross-cutting, mitering. The rip blade is used for smooth with-the-grain cutting. Special plywood blades have extra-fine teeth to produce smooth, splinter-free cuts.

Do not use one of your best blades to cut Formica and other plastic laminate sheeting, or tempered Masonite hardboard. An old, dulled blade will do for this. Better still use a carbide-tipped blade that will give long service and can also be used for such materials as asbestos, thin brass sheeting, and aluminum.

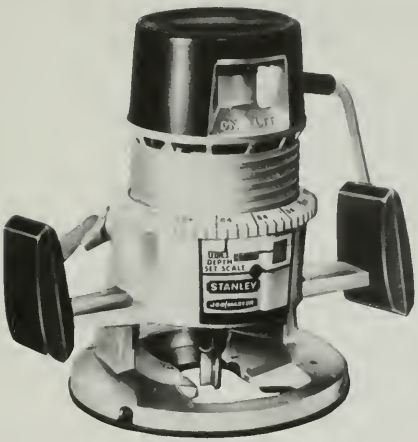
For brick and other masonry, use only special cut-off wheels designed for the purpose, available in 6-, 7- and 8-inch diameters. These cut-off wheels must be used cautiously and according to the manufacturer's directions.

*The router.* Basically, the router is a motor, like an electric drill. But there are considerable differences that enable the router to produce a great range of work. With the dozens of cutter bits and various templates that are available, you can use the router to decorate the edges of furniture projects, cut circles and rabbets and dado grooves, plane door edges, make dovetail joints for drawers, even turn out your own moldings for picture frames and other purposes. The router cuts precise mortises for door hinges and locks. It is also an essential tool for trimming the edge of plastic laminate sheeting. With the router, also, you can do decorative carving on walls, engrave your name or address on the garage door panels, make interesting filagree panels.

Fundamentally, the router does the work of a shaper. The most important factor is that the work remains fixed, it is the tool that moves, the very fast motor and tiny bit making the cut that is so precise and smooth that no further attention is required.

The router is used with one of the variously shaped router bits designed to make straight cuts for grooves or rabbets, or are fluted to produce a decorative edge such as coved, chamfered, V-shape, bead, or other style. Setting of the bit in the chuck is important, as the length or exposure that it extends below the router base plate affects the position and shape of the cut. This exposure is adjusted by revolving the router base to the position desired, and locking the base knob. The chuck is locked with an open end wrench. The bit must be inserted at least ½-inch of its length into the chuck for secure grip. Safety warning: be sure to pull the plug from the electric outlet every time you change or adjust a bit.

For inside routing, a template may be used to guide the router bit for straight cuts, or the router moved along freehand to follow a penciled outline. For precise duplication of a design in several panels, a pattern




▲ *The router is a useful power tool for precision joining and decorative detailing, such as coved edges of plywood cabinets. The wide assortment of router bits available permits dadoing, rabbeting and shaping as well as engraving and filigree cutouts.*

template is tacked or clamped to the work surface, the router plate moved against the template.

Edge shaping is guided by a pivot that extends beyond the cutting edge. This pivot rides against the edge of the board. Move the cutter from left to right whenever it is practicable, but do not start at the end of the board as the pilot will not be seated before the bit has cut into the wood. Rather, begin a slight distance from the left-hand edge, move the router toward that edge, then come back to where you started and complete the cut by slowly moving the opposite way to the right. As you come to the end of the board, hold the router steady, sweep it outward as it completes the cut; otherwise the bit will tend to turn itself around the corner and start the cut on the other edge.

Dovetail joints for drawers, once the product of only the most skilled cabinetmakers, now can be done easily by anyone using a router and special template, into which both mating pieces are clamped. Both parts are cut at the same time, the router merely moved into and out of the template notches. The parts should then join perfectly, forming the most durable type of drawer joint.

For trimming the edges of kitchen counters and furniture, a special laminate trimming kit with a carbide-tipped bit is required. A delicate adjustment control permits flush trimming to produce a hairline along the edge. The templates and mortising bit of a complete door hanging kit assure perfect mortising and alignment of butt hinges. This kit may be rented for the short period that it would be needed, rather than purchased.

Routers vary in motor horsepower, speed and convenience features. The lower price range, with ½- to ¾-hp. motors that deliver up to 20,000 rpm. no load speed, is usually satisfactory for the home workshop when used primarily for a short decoration and similar jobs; better quality routers of 1- to 1½-hp. with speeds up to 25,000 are heavy-duty and should be selected when such jobs as dovetailing and extensive edge trimming are contemplated. The latter also have a larger collet permitting use of a wider range of cutter bits with ½-inch shanks. Contrary to drills in which the highest speed is in the lower priced tools, very high speed is desirable in routers because it results in the smoothest cutting. The more powerful, higher priced routers also have the higher rpm.

Accessories such as adjustable edge guides and trammel point attachments expand the range of the router and are worth purchasing. Most important, a good collection of assorted cutter bits will open the way for new and better looking home projects.

*See also:* DRILL ATTACHMENTS, POWER; DRILL PRESS; JIGS; LATHE; RADIAL ARM SAW; ROUTER; SABER SAW; SANDERS; SAW; TABLE SAW; TOOL TECHNIQUES.

# Power Tool Safety Check Lists

**These safety rules were developed for the construction industry, but they can save the householder from injury just as well as the professional construction worker**

## SAFETY RULES FOR POWER TOOLS

Following is a list of safety rules for power tools based on those developed as part of an overall safety program by the Power Tool Institute in cooperation with various construction trades, labor unions and the Federal government.

1. Know the tool you are using—its application, limitations and potential hazards.

2. Select proper tool for the job. Do not try to tackle a big job with an undersized tool—makeshift tools can cause accidents.

3. Ground all tools—unless double-insulated. If tool is equipped with three-prong plug, it should be plugged into a three-hole electrical receptacle. If adapter is used to accommodate a two-prong receptacle, the adapter wire must be attached to a *known ground.*

4. Remove adjusting keys and wrenches before turning on tool.

5. Keep work free of clutter—boards, boxes, debris, tools, etc.—that can be tripping hazards.

6. Keep guards in place and in working order. Do not remove or wedge out of the way.

7. Always be alert to potential hazards in your working environment such as damp locations, presence of highly combustible materials—gasoline, naphtha, etc.

8. Avoid accidental startup. Make sure switch is "off" before plugging in cord—or when power is interrupted. Don't carry plugged in tool with finger on switch.

9. Make sure saw blades, drill bits, router cutters, etc. are sharp, clean and regularly maintained.

10. Use only recommended accessories. Follow manufacturer's instructions.

11. Do not force tool. It will do a better and safer job at its designed speed.

12. Use safety glasses. Also face or dust mask if operation requires it.

13. Do not overreach. Keep proper footing and balance at all times.

14. Never leave tool running unattended. Don't leave it until it comes to a complete stop and is disconnected from power source.

15. Do not surprise or touch anyone operating a power tool. The distraction could cause a serious accident.

16. Never adjust, change bits, blades or cutters with tool connected.

17. Dress properly. Avoid loose clothing that could catch in moving parts. Wear rubber boots in damp locations.

18. Secure work. Use clamps or vise to hold when practical. It frees both hands to operate tool.

19. Do not use tool with frayed cord. Have cord replaced. Use only heavy-duty U.L. listed extension cords of proper wire size and length.

20. Never brush away chips or sawdust while tool is operating.

21. Service any tool that shows the slightest defect or is not operating properly.

22. Store tools in a dry, secure location where they will not be tampered with, especially by children.

## TOOL MAINTENANCE CHECK LIST

**Cord Sets and Extension Cords**—Visually check cords for cuts and/or other previous damage. Examine plugs for damage to ground terminal. If ground terminal is missing, the plug should be replaced.

**Switch**—Check mechanical operation of switch with plug disconnected. It should be free of excessive drag and binding. Also check for secure mounting and any other obvious defects.

**Chucks, Collets or Other Tool Holding Devices**—Check that parts are in good functional condition. Also check that proper size wrenches and keys are available.

**Guards**—Check guards for proper installation. Moveable guards should function smoothly.

**Housings and General Hardware**—Check general condition of housing for defects and/or damage. Replace missing hardware and tighten all loose bolts and/or fittings.

**Blades and Bits**—Check for any damage or defects. Resharpen as required and reinstall in accordance with manufacturer's recommendations. Use only those accessories recommended by the manufacturer.

**Adjustments**—Make any necessary adjustments per manufacturer's recommendations.

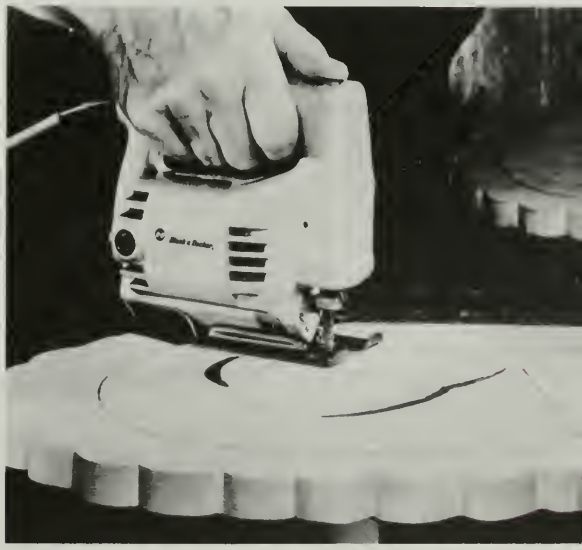
**Maintenance**—Follow manufacturer's recommended maintenance procedures.

**Mechanical Operation**—If possible, the tool should be rotated by hand to assure that all parts are operating freely and no internal damage to drive train exists.

**Leakage Current Test**—This test should be performed using an approved fault interrupter. The test procedure should be performed per the manufacturer's instructions with the tool being in each of its modes of operation i.e. forward, reverse, etc. The tool should be operated at no load to check commutation and to listen for unusual noise which might indicate mechanical trouble in drive train, bearings, etc. Any tools which trip the GFI should be immediately identified with a tag as unsafe and be repaired by a qualified person in accordance with the manufacturer's recommendations prior to using it again.

*When you are using a power tool, make sure your stance is secure and that you are not wearing loose clothing.*

*Is the blade sharp? Is the work area uncluttered? Are all keys or locking tools removed? Be sure you can answer all these questions with a "yes" before you even turn the switch on.*



# How to Make Linoleum Prints

**You can use this simple, inexpensive technique to make graphics to decorate the walls of your home or to print your own hand-made greeting cards and invitations**

YOU CAN USE LINOLEUM block prints as posters, hand-made party invitations and announcements, Christmas cards or as graphic decorations for your home.

The four-step technique is simple—unchanged in principle since its invention, probably by the Chinese some time before 800 A.D.—and requires no expensive equipment.

All it takes are a set of linoleum cutters; some linoleum blocks or sheets; a few tubes of ink; a roller and a flat smooth sheet (a pane of glass or an old cookie sheet will do), and some good quality paper. The paper should be soft and absorbent. Hard, glossy papers are difficult to work with.

You can assemble a complete package at a hobby shop or art supply store for about $10 and the results, embodying your imagination and effort, will be irreplaceable at any price.

The process comprises these four steps: transferring the image to the linoleum; carving the linoleum surface; inking the linoleum, and printing the image on paper.

You can draw the image on the linoleum freehand or you can trace it. If you plan to use letters or numbers, remember that what you see on the surface of the linoleum will be the reverse of what is printed on the paper. One simple way to handle this problem is to trace the image on a piece of tracing paper the way you want it to appear. Then, turn the paper over so you see the reverse image when you trace it on the linoleum.

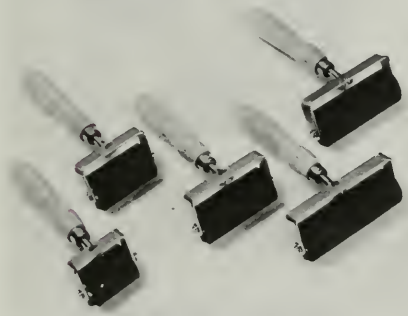
Hold the tracing paper in place on the linoleum with masking tape at one edge. Slide a piece of carbon paper beneath the tracing paper, so the carbon side is next to the linoleum. If the dark color of the carbon maker makes it difficult to see the design on the tracing paper, insert a piece of white paper between the carbon paper and the tracing paper. Trace the image with a soft lead pencil.

When the image is transferred to the linoleum, outline it with a No. 1 cutter, called a small veiner. Remember that the part of the surface that you cut away is the part that will not print. The part that remains is the part that will transfer ink to the paper.

**prints, plastic:** see science projects
**print washer:** see darkrooms
**privacy, telephone:** see telephone

*Assortment of linoleum cutters with holder.*

WRONG
If the drawing on the linoleum looks like this . . .
the print will look like this.
RIGHT
If the drawing on the linoleum looks like this . . .
the print will look like this.



*Ink rollers come in a variety of widths and diameters.*

Remove any large areas that you want to print white with a No. 5 cutter. This is a gouge. Use it with bold strokes, even leaving occasional high spots that will add character to the finished print. The small veiner, the gouge and a third cutter, the knife, or No. 6 cutter, are all that you need to execute almost any design. The knife is for fine work, such as on letters and numbers.

Play it safe while carving and tack down the linoleum sheet with map pins, and always push the cutter away from your body and your free hand. Keep your free hand near your body. Never let it rest on the

*Outline drawing with a small veiner as at left. Gouge out large areas (center) and finish fine details with a No. 6 knife.*

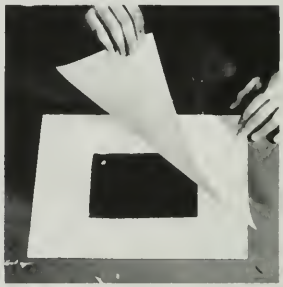
▲ *Tracing the image on the linoleum block.*

▲ *Use a small veiner (No. 1 cutter) to outline the drawing. Do not cut out lines. Cut around them. What you cut away will not print.*

▲ *Remove large areas of white with a gouge (No. 5 cutter) using smooth bold strokes. High spots left between strokes will add character to the completed print.*

◀ *Roll out a dab of ink in a flat, smooth surface. The inked area should be eight or nine inches long and slightly wider than the roller.*

▲ *Work the inked roller over the linoleum cut with crisscross strokes.*



▲ *Place the paper on the linoleum carefully so there is no lateral motion.*

▲ *Rub paper firmly with the back of a spoon. Hold the paper with one hand so it does not slip. Rub slowly with short back-and-forth strokes, taking care to cover the whole surface.*

OVER INKED

UNEVEN

GRAY PRINT

RIGHT

▲ *Getting the right ink coverage may take two or three tries.*

working surface on the far side of the linoleum or next to it.

Before inking the linoleum, brush away all scrap pieces and slivers. Squeeze a small dab of ink onto the ink sheet and roll it out with the roller until it covers evenly an area about eight inches long and a little wider than the roller.

Work the inky roller over the linoleum with crosscross strokes, making sure to cover it evenly, including corners and edges. Inking must be just right. Too much ink and the print will be muddy, too little and there will be bare spots. Getting the right ink coverage may take two or three tries.

When you are finished, be sure to clean the roller and the inking sheet with water. Dried ink can spoil them.

Print the image by laying a piece of paper over the inked linoleum. Do this with great care so the paper does not move or slide over the inked surface and smear the image.

Use the bottom of the bowl of a table spoon as a burnisher to press the paper against the linoleum with gentle, short back-and-forth strokes. You don't have to press hard, but be sure to cover the entire surface. And, do not let the paper move.

Starting at one corner, lift the paper gently from the linoleum and the print is completed. Repeat the printing process to make as many copies as you like. If you wish to change colors, simply change inks.

Once you have mastered the basic technique, you may want to try variations, printing in two colors, for example. This is done by tracing parts of the image on two different sheets of linoleum, one for each color, making two engravings and printing each sheet of paper twice. Another graphics technique is to print a design and then color it in a variety of hues by hand. F.C.

*See also:* CERAMICS; CRAFT PROJECTS; DECORATIONS; DECOUPAGE; EGG DECORATIONS; HANDICRAFTS; INLAY WOODWORKING.

# How to Build an Overhead Projector

**You can fill an entire wall with brilliant images or optical experiments with this build-it-yourself device**

YOU'LL SEE THINGS in ways you have never seen them before when you use this overhead projector to magnify your experimental setups into eye-popping images big enough to fill the entire wall of a room. This king-size overhead projector accepts subject matter up to ten inches square, and enlarges it into a brilliant image eight feet across from a remarkably short projection distance of only 12 feet. Moiré patterns, polarization colors, ripple tank patterns, and many other science effects take on new meanings when observed with the aid of a good overhead projector. And this self-built projector, if constructed with care, will perform as well as a commerically-built unit costing $150 or more.

You may already have some of the parts on hand—like a small motor to operate a cooling fan. You can buy the more important construction items from a scientific supply house and pick up what else you need from local hardware, lumber and electronics supply shops. Do not attempt to use any make-shift substitutes for the following: the Fresnel condenser, two 88 mm. diameter meniscus lenses, and the 500-watt quartz-iodine lamp with matching reflector.

Remember that this is an optical device, and it will work properly only if you build it with care, paying special attention to proper lens and lamp alignment. If you are reasonably handy with wood-working tools, and patient enough to use a square frequently, this project should not be overly difficult. This is not a one-day construction job, so don't try to rush the work.

The special quartz-iodine lamp provides a lot of light and a considerable amount of heat; so provide all the ventilation and forced cooling indicated in the plans. Be very sure to wire the fan motor and lamp so that the lamp cannot be turned on unless the fan is operating.

*Building the box.* Before starting to build the box, make certain that your fan and motor will fit in front of one of the louvered openings without crowding the lamp which

**projects, boat building:** see boat building projects
**projects, craft:** see craft projects
**projects, science:** see science projects
**propagation tub:** see gardening
**pruning:** see gardening

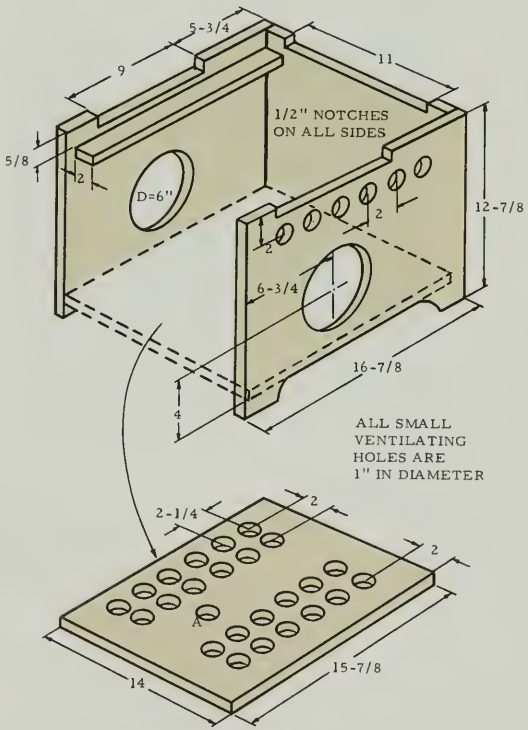
should be located midways between the louvered openings. Cut the bottom piece to the dimensions shown and drill the 24 one-inch ventilating holes. Do not at this time drill the extra hole, marked A; you will locate that one when you install the lamp.

The two identical end panels are 14 inches wide and 11⅝ inches high; each has a ½-inch deep notch cut into its upper edge to provide air circulation between the Fresnel lens and the top glass plate. The side panels, which are mirror images of each other, are higher than the end panels so as to provide feet to keep the box bottom off the supporting table. If you wish, cut all the wall panels the same height and add separate feet to provide the required 1½ inches of clearance necessary for proper bottom ventilation. Add the ½-inch deep off center ventilating notches along the top edges, then locate and drill the six one-inch ventilating holes. Note that the two six-inch diameter holes, for the aluminum louveres, are also somewhat off-center, closer to the front of the box than the rear. If you cut these openings accurately, the louvers will lock neatly into place when pushed in.

When you are sure that the sides and bottom fit perfectly (are your cuts all properly squared?), glue them in place with contact cement, then nail firmly with wire nails. You can now add the two ½ x 2-inch strips, running the length of the box, ⅝-inch below the top edges. These will support the Fresnel condenser lens.

The box top is also made from ½-inch thick plywood. Note that it is about two inches wider and longer than top of the box to permit air movement through the long notches cut into the top edges of the box. Lay out a 10 x 10-inch square, 2¾-inches from the front end. Cut this out as evenly as possible using a saber saw or keyhole saw. A ragged cut will produce a ragged edge on your projected image. If this happens, add a cardboard mask to improve the appearance of the image. Around the opening, lay out another square ½-inch larger all around. Cut this down just enough to bring the top of an 11 x 11 piece of *double weight* window glass flush with the wood surface. Later you can glue the glass in place using ordinary household cement. The joint can be sealed with strips of plastic electrical tape to improve the appearance and to keep spilled liquids from seeping into the box.

Nail ¼ x 1¼-inch strips of wood around the top panel, as shown, to form a light-




*Light box is made of ½-inch thick plywood. Thirty-six one-inch holes, two louvered six-inch diameter holes, and long notches on upper edges of box are all vital in order to obtain adequate ventilation. The projector will work correctly only if you build it with care, paying attention to detail. It's not a one-day job, so don't try to hurry.*

baffle and to dress up the edge. The notch at the rear of the panel should not be cut until you have added the vertical post to the rear of the box.

*Focusing assembly.* Make the 37-inch long post from hardwood so that it will resist warping. Mount the post on the rear of the light box, using 1½-inch carriage bolts. Sink the bolt heads about a third of the way through the post. If you file the upper bolt hole in the box panel into a short, horizontal slot, you can easily adjust the vertical alignment of the post at any time just by loosening the nut on the upper bolt.

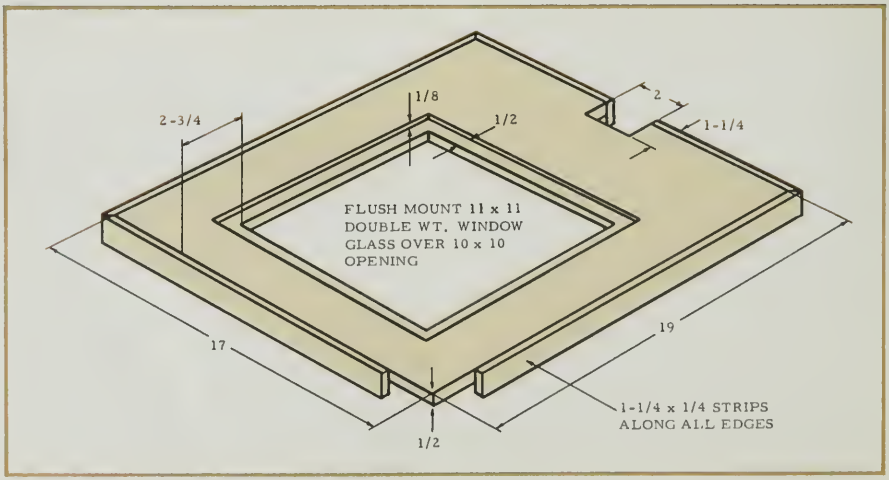
Cut the 15-inch sliding lens support arm from ¾-inch pine (well dried and flat). Near one end cut a rectangular opening just large enough for a smooth, sliding fit on the post. Some liquid wax rubbed onto the post will help the sliding action. Avoid an oversize hole that would introduce wobble to the arm. A 3½-inch hole is cut into the other end of the arm to take the metal tube of the lens assembly.

Using scrap pieces of ¾-inch pine and ¼-inch plywood, make the wooden sleeve that is glued and screwed to the under side of the lens support arm. This sleeve should also slide smoothly on the post. Make sure that the upper surface of the lens support arm is at right angles to the post.

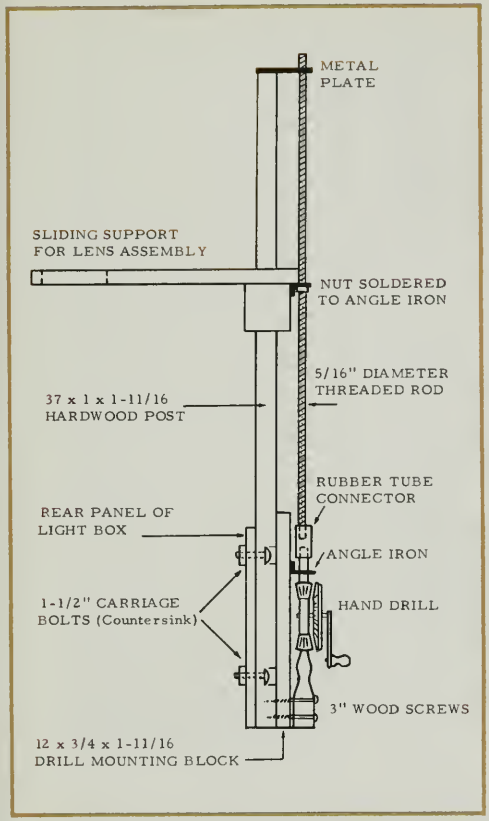
At the bottom of the post, add a drill mounting block made from ¾-inch pine, as shown. To this, fasten an old hand drill (or buy the cheapest one you can find) using two long screws passed through holes drilled into the handle. The upper end of the drill is kept in vertical alignment by means of a small angle iron. Fasten a 5/16-inch diameter threaded rod to the drill (after removal of the chuck) by means of a rubber tube connector. Keeping the rod parallel with the post, lay out a metal plate to hold the upper end of the rod. Screw this plate to the top of the post with two screws. The rod should turn freely in the hole drilled into this plate. Add a small plastic bushing to eliminate a slight metallic clatter.

Now add a small angle iron to the rear of the lens support sleeve after soldering a nut to a hole on the projecting arm of the

*Box top must be made from a perfectly flat piece of 1/2-inch plywood. A rabbet cut around the 10 x 10-inch opening brings the double-weight window glass flush with panel surface.*

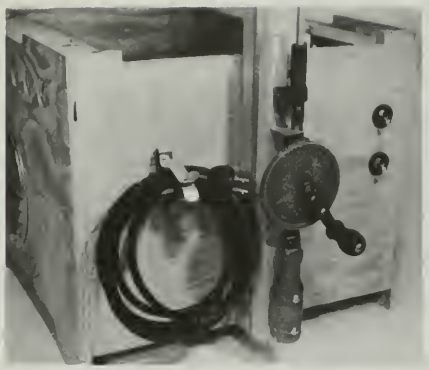


*How to Build an Overhead Projector*


METAL PLATE
SLIDING SUPPORT FOR LENS ASSEMBLY
NUT SOLDERED TO ANGLE IRON
5/16" DIAMETER THREADED ROD
37 x 1 x 1-11/16 HARDWOOD POST
RUBBER TUBE CONNECTOR
REAR PANEL OF LIGHT BOX
ANGLE IRON
1-1/2" CARRIAGE BOLTS (Countersink)
HAND DRILL
3" WOOD SCREWS
12 x 3/4 x 1-11/16 DRILL MOUNTING BLOCK

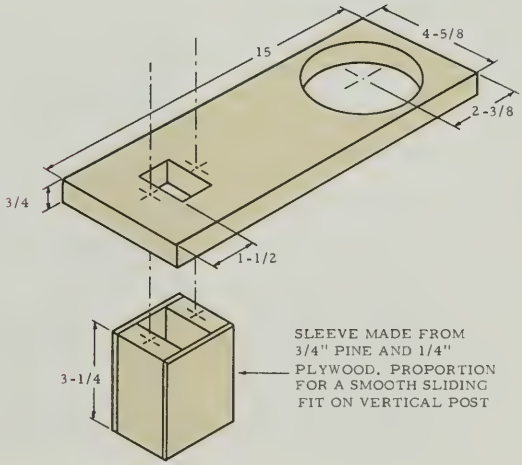
*Optional focusing rig uses a threaded rod, turned by a hand drill to move the lens assembly support arm up and down the post.*

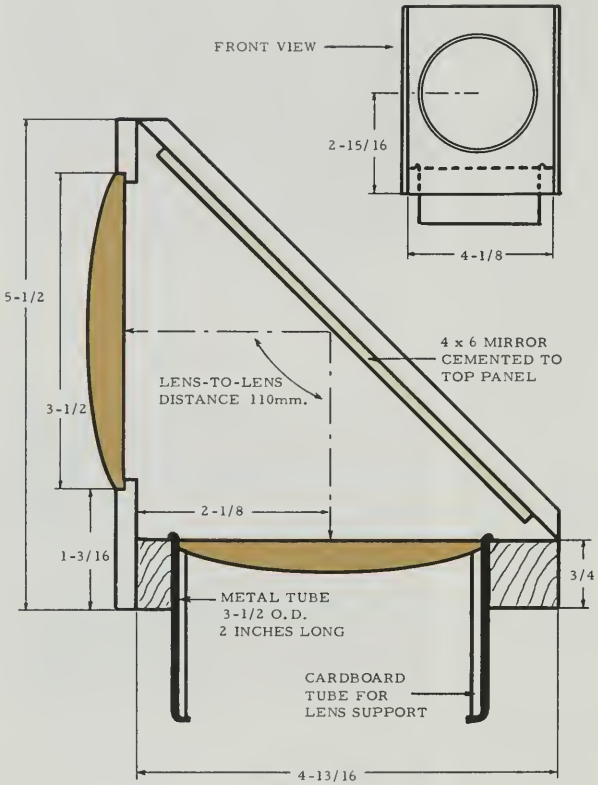
*Support arm for the lens assembly is made of 3/4-inch pine and 1/4-inch plywood. The sleeve must slide on the vertical post smoothly, with no binding or wobble. The focusing rig here allows for smooth, fingertip control of focusing; and it's simple and rather inexpensive for you to construct. See text and drawing for details.*



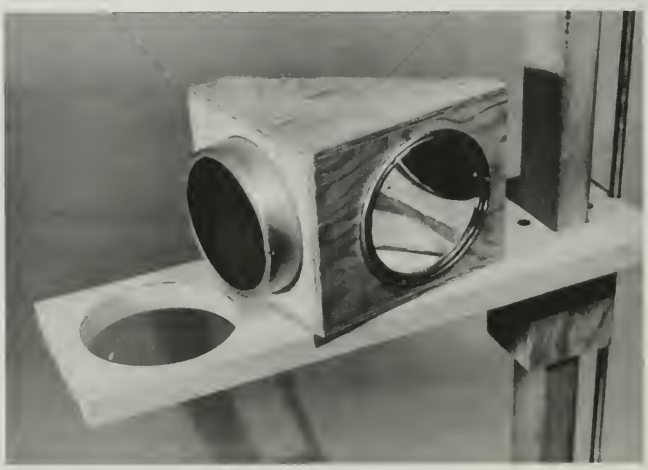
*Old hand drill makes an efficient focusing system. Toggle switches are placed on the rear panel, close to the focusing device. Note spring clip used to hold power cords.*

*Support arm for the lens head must be at right angles to the vertical post. Do not paint the vertical post; wax it to obtain smooth sliding action of the wooden sleeve.*






*Lens head must be constructed carefully so that the lenses are at exact right angles to each other. The mirror must make an exact 45° angle with each lens for proper results.*



*Metal tube, projecting from the lens head, drops into hole on the support arm. Head can be swiveled to beam projected image in any direction. Paint inside of head black.*

angle iron. You can make a suitable angle iron by snipping off part of a BX cable clamp of the type used in junction boxes. This provides two screw holes and a properly positioned hole for the nut. If everything is properly aligned, you will find that the lens support arm slides smoothly up and down the post as you rotate the hand drill.

*Lens assembly.* Proper optical alignment can be obtained only if the two projection (meniscus) lenses are at right angles to each other and if the mirror is at an exact 45 degrees to each lens.

Start by making the base block ($4\frac{13}{16}$ x 4⅛ inches) from ¾-inch thick pine. Cut a 3½-inch diameter hole into this block, centered 2⅛-inch from the front end of the block. The rest of the lens head is made from ¼-inch plywood. The front panel is 5¼ inches high, 4⅛ inches wide. Center the 3¼-inch lens opening $2\frac{15}{16}$ inches from the bottom edge. Note that this opening is slightly undersize. Cut a ⅛-inch deep ledge all around the hole so that you can set the lens part-way into the panel. You can glue the lens in place, or use a metal retainer ring, as shown.

The sloping top panel is 4⅝ inches wide so that it overlaps the side walls. Note where the top panel contacts the top edge of the front panel and the rear of the base. A 4 x 6-inch mirror is glued to the underside of the top panel.

Your biggest problem will be to find a metal tube 3½ inches in diameter, and 2 inches long. You may have to fashion it from sheet metal. An old percolator coffee holder might be just right after the bottom is cut out to leave a ⅛-inch wide lip to support a heavy cardboard tube inside the metal tube. The tube should form a snug, sliding fit with the hole cut into the base of the lens head. The second lens is glued to the top of the inner cardboard tube, curved surface down. After assembly, tack the top panel on lightly with a couple of wire nails until the unit has been tested. Before it is fastened in place permanently, paint the inside of the head with flat black paint, and clean the lens and mirror surfaces thoroughly.

The projecting section of the metal tube drops into the round hole on the lens support arm. It should swivel smoothly so that you can beam your projected image in any direction. Drill two small holes through the lower edge of the metal tube to take short nails that serve to keep the head on the arm without interfering with the swivel action. If the tube is long enough, a heavy rubber band snapped around it will serve as well.

*Motor mount.* Attach the fan blade to your motor and test to make sure that it pushes air away from the motor, not toward it. Now position it inside the box, exactly opposite one of the louvered openings, and rig a suitable mounting. One way is to rest the motor on a wood block screwed to the bottom of the box, and tie it down with four metal straps cut from sheet metal, as shown.

*Lamp assembly.* Make a wood block 1¾ inches high by sandwiching a 4 x 2½-inch piece of ½-inch plywood between two equally proportioned blocks cut from ¾-inch pipe. Drill a hole in one end of the block (⅜-inch from the top) and screw in a length of ¼-inch threaded rod or any other long bolt. This will hold the vertical plywood panel by means of a washer and wing nut passed through a vertical slot that permits the vertical panel to be moved up and down for lamp adjustment.

Mount the lamp socket at the top of the vertical panel, as shown. The reflector must be mounted directly beneath the lamp so that the bottom of the reflector is just 30 mm from the center of the lamp filament. Make a reflector holder by cutting the head from a 2-inch bolt. Using a hacksaw, cut a slot into the end of the bolt. Now flatten the end of a short length of stiff wire (coat hanger) so that it can be forced into the

slot, and solder in place. The reflector has two metal tabs, with holes, that can be turned down so that the wire can be passed through them. Mount the reflector holder on the vertical panel and slide the reflector along the wire until it is directly beneath the lamp filament.

WARNING: The special quartz-iodine lamp has a very long life (estimated about 2,000 hours), provided you handle it properly. Never handle it with your bare hands, but hold it with a piece of clean cloth or wear clean cotton gloves when working with the bulb. The natural oils on your hands will materially decrease the life of the bulb. If you do touch it, clean with alcohol before putting it to use. Also, do not look directly at the bulb when it is turned on; the intense light can be harmful to your eyes.

*Electrical wiring.* Mount two toggle switches in the rear panel of the light box. Use switches having stems long enough to reach through the ½-inch thick plywood wall. Wire the lamp and motor to the switches, as shown. Note that the lamp can be turned on only after the fan is operating. This system eliminates the possibility of ruining the lamp through overheating. It's also a good idea to keep the fan running for about five minutes after the lamp is turned off. When you wire in the lamp, leave enough slack in the wire to permit moving the lamp assembly an inch or so in all directions.

*Alignment procedure.* Remove the lens head from its support arm and position the support about halfway up the post. Cut a piece of Masonite or heavy cardboard to fit over the end of the support arm, tape in place, and mark the circular opening onto the Masonite. Find the center of this circle, drill a small hole at that point and suspend a plumb bob by passing the string through the hole. Drop the plumb bob into the box and position the lamp filament directly below it, tacking the lamp base onto the box bottom lightly. Remove the bulb and reflector and drill a bolt hole through the lamp base and the bottom of the box. Enlarge the hole (A) in the box bottom to 1-inch in diameter. Now pass a bolt through the lamp block, through the 1-inch hole, and secure with a wing nut and a large washer (2½-inch diameter). Replace the bulb and reflector and once again position the filament under the plumb bob.

Rack up the lens support arm so that the blumb bob is near the top of the box. Position the Fresnel lens on the 2-inch slats inside the box (a label on the lens indicates which side should go down) and align the center of the lens under the plumb bob. Use tape or brads to keep the Fresnel lens temporarily in place.

Remove the plumb bob and put the lens head back on the support arm. Set the overhead projector about eight feet from a projection screen (hang up a bed sheet if a clear white wall is not available). Place the lid on the box, centering it properly. Incidentally, small wood cleats nailed to the underside of the lid, at each corner of the box, will make accurate positioning of the lid fast and easy.

Turn on the fan and light. You should have a bright square of light on the screen, but it probably shows a lot of color fringes. Don't worry.

If the edges of the screen image do not appear sharp, try sliding the metal tube in the lens head upward to move the lower lens closer to the front lens and mirror. This should make the outlines of the projected image sharp and clear.

Now reach under the box, loosen the wing nut, and gently shift the lamp about to get the most even illumination possible. You can reach this nut easily if you place the box on two chairs that face each other and are slightly apart. When the illumination is uniform, tighten the nut.

The color fringes you will probably see provide a clue to the needed *vertical* adjust-

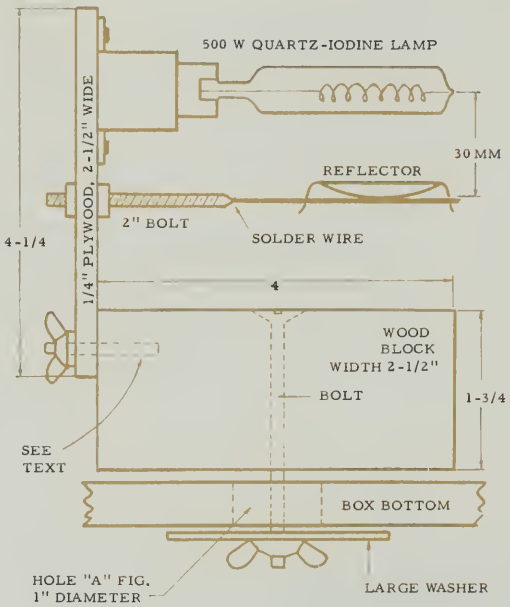
ment of the lamp. Remove the box lid and Fresnel lens and adjust the vertical lamp panel upward if you saw reddish-brown fringes, downward if you saw blue fringes. Be patient, you may have to check and re-check these various adjustments several times but you should eventually obtain a brightly-lighted image virtually free of any color fringes.

If you change the distance drastically you may have to re-adjust the system slightly. Chances are that this will not be a problem unless you want to project a super-size image in a very large room.

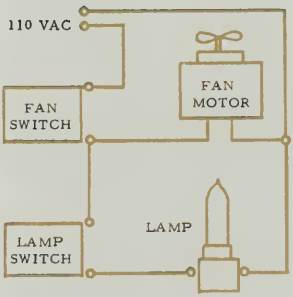
A few final touches will make your overhead projector complete. The inside of the light box, as well as the interior of the lens head, should be painted dull black. You can paint the outside any color that pleases, but do not paint the vertical post. Just sand lightly to clean, and wax with paste wax.

*Start experimenting!* You can perform all sorts of wondrous experiments with your overhead projector. For a start, place two flat pieces of window screening on the glass plate and rotate the top screen. You will see some fascinating moiré patterns—king size!

Place a transparent glass or plastic tray




*Lamp mounting can be adjusted from outside the light box by loosening the lower wing nut and moving the bolt in the one-inch diameter hole. The lamp to reflector distance must be exactly 30 mm.*




*Simple wiring of fan motor and lamp to two toggle switches prevents turning on the lamp before the fan is operating. Run fan after lamp is turned off.*

*The heavy-duty motor and fan provides excellent forced cooling. Make a note of how the motor mounts on block with metal straps.*

on the projector and add a little water. Tap the water with your finger, or let water drop onto the surface from a medicine dropper. You now have a ripple tank for wave studies. Put the medicine dropper under the water surface and squirt a jet that can be seen as a fast-moving shadow turbulence.

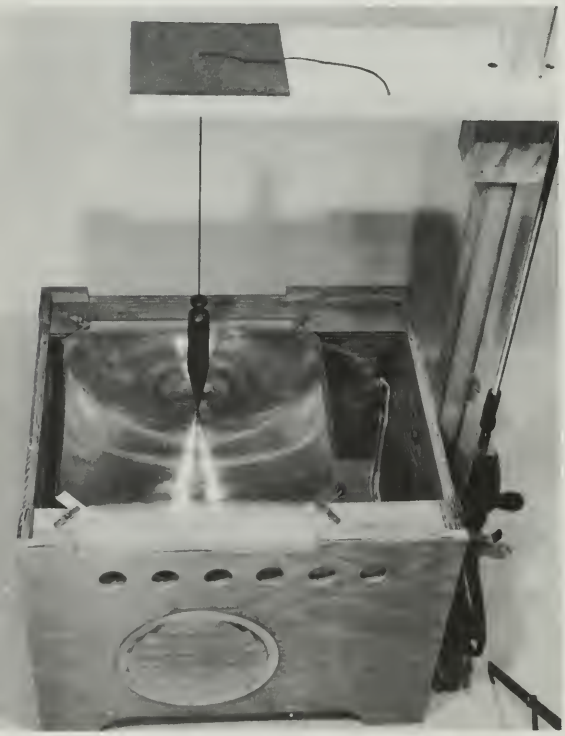
Experimentation using polarized light can be especially dramatic. Tape a 10 x 10-inch sheet of polarizing filter material to a sheet of ordinary window glass and place on the light box, glass side up. Place a smaller piece of filter material over the vertical lens in the lens head, and arrange it so that it can be rotated. When the filters are so oriented that they stop most of the projector light (extinction position), plastic objects will show brilliant polarization colors, as will those that are bent, squeezed or stretched. You can buy over 500 square inches of polarizing sheet material for about $4; this does not provide complete extinction but quite enough for most experiments. Better grade material is more expensive and you would need one 10 x 10-inch sheet plus one 5 x 5-inch sheet.

What else can you do with the projector? How about big blow-ups showing magnetic fields as they effect iron filings sprinkled on glass. How about creating some enlarged Chladni figures? Physics textbooks describe this phenomenon. Biology students can find many uses for the projector—for example, showing huge spider webs after they have been transferred to sheets of glass.

When your scientific pursuits are at a low ebb, try using the projector to create some unique "color shows" similar to those used to provide glamorous and exciting mood atmospheres in discotheques and other places of entertainment. For a starter, make some motorized color wheels, or use moving color wheels in combination with moiré pattern transparencies. Another approach is to dribble dye materials—liquid or powder—into water to create colorful random patterns as the dye materials diffuse and dissolve. Want to make the show "bubble" with excitement? Throw in an Alka-Seltzer tablet. J.H.

*See also:* SCIENCE PROJECTS.

*Use plumb bob to align lens head perfectly with the lamp filament and center of the plastic Fresnel condenser lens. Note metal hold-down clips at corners of Fresnel lens.*



**WHERE TO FIND IT**

The projector shown here is a modification of an Edmund design. An overhead projector kit, quartz-iodine lamp, lamp socket, motor, fan, mirror and reflector are available from Edmund Scientific Co., Edscorp Bldg., Barrington, N. J. 09007. The company also offers two pamphlets, *Fun with Fresnel Lenses* and *The Edmund Unique Lighting Handbook*. Write to them for complete information.

# How to Operate a Public Address System

**PA systems rarely work quite as well as intended. Here's how to get the kinks out when things go wrong**

TEN MINUTES to starting time. The Royal Grand Potentate has come all the way from Crows Canyon for the annual lodge banquet, and you know what a reputation he has for laying 'em in the aisles. The MC makes a perfunctory check of the public address system with the *one-two-three* testing routine. Nothing happens!

Normally stable as the Rock of Gibraltar, the MC is suddenly reduced to panting panic as he hammers the mike and hollers for the manager. And then his eye lights up with the hope of desperation as he spots you, the lodge electronics hobbyist, at a forward table. Suddenly it's your tub of transistors.

*Enter thinking.* You make sure the mike's own switch is *on,* and you work it back and forth to clear the contacts. You gently tap the microphone after tightening the cable connector on the mike head, and you finally determine the system is truly a corpse. The connector at the other end of the cable is firmly snapped into the audio wall socket. A harried scan of the room discloses the amplifier on a shelf at the rear. The red pilot light shows the AC is OK. The mike volume control and master gain pots are set near mid-range so up to here, all systems are go.

You gently slide the amplifier around and see no unattached wires hanging loose and no stray strands shorting the loudspeaker-connection screws. Turning off the power briefly, you tighten the screws with your nail file or pocket knife and firmly seat the two mike connectors.

Two mike connectors? You dash to the other microphone—the one for the guest speaker—and *Eureka!* It works! So while a hastily recruited lodge brother talks into the good mike, you identify the defective channel at the amplifier by disengaging the mike cable connectors one at a time and noting when the signal stops. Then putting your finger on that channel's now-exposed single (Amphenol) or triple (Cannon) mike input terminals on the amplifier, you get a satisfying buzz from the speakers.

So you now know the amplifier channel is good and the mike or its cable is bad. By this time, the assistant manager has arrived. In no time at all, he sets up a spare mike.

*Pause smiling.* You heave a mighty sigh. The MC looks ten years younger as he

**pumice:** see abrasives
**pump, fuel:** see fuel pump
**punch:** see hand tools
**quartz crystals:** see electronics
**quick-light:** see camping equipment

*Rear of S20 reveals two mike inputs of Amphenol type at far right, remote control connector at right of speaker terminals. Latter is for pots to control mike volume.*

*Typical of public-address amplifiers is Precision Electronics' Model S20. Power monitor (at right) is neon lamp which flickers when pots are set for desired output.*

confidently repeats his test routine—and promptly ages again as the system howls into feedback. As the guest speaker enters, the MC tosses the ball of wax back to you. So what now, Marconi?

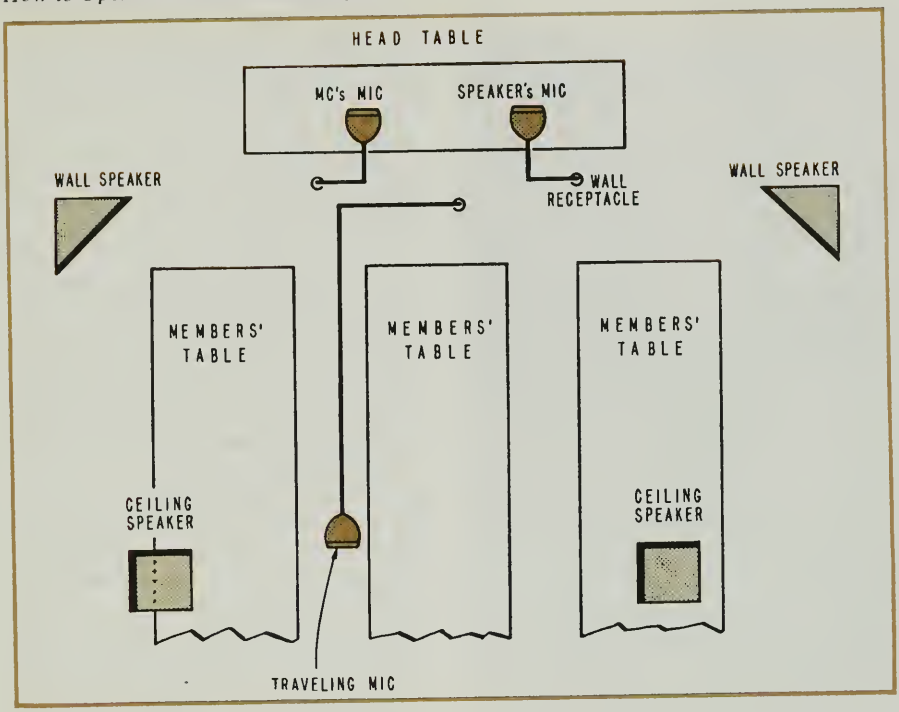
Feedback, hmmm. Maybe in checking over the amplifier connections, you accidentally advanced the mike pot? No, it's OK but you drop it a bit. No dice. Another slight drop, and now the howl is gone, and so is the needed volume. Could the tone control have been jostled down into the bass region where feedback is most likely?

Nope, it's right in the middle of the range. Then your eye falls on the MC's replacement microphone and you notice it looks a bit different from the original. In fact, it's a non-directional unit and it's picking up some of the loudspeaker output that was blocked out by the original directional mike.

So you mentally tick off possible solutions as the guest speaker is being escorted up the aisle toward the head table. You could turn down the gain to reduce system sensitivity and have the MC buddy up to the mike to compensate. Or you could raise the mike higher on its stand and angle it downward, hoping for a little instant directionality.

But wait a minute. Here comes the assistant manager again and he's carrying the original mike. Beaming, he puts it back on the MC's stand and explains he soldered a broken connection in the connector receptacle. And gratefully you hear the clear, ringing tones from the loudspeakers, "Ladies and gentlemen . . ."

*Act II.* In show business, they'd call this

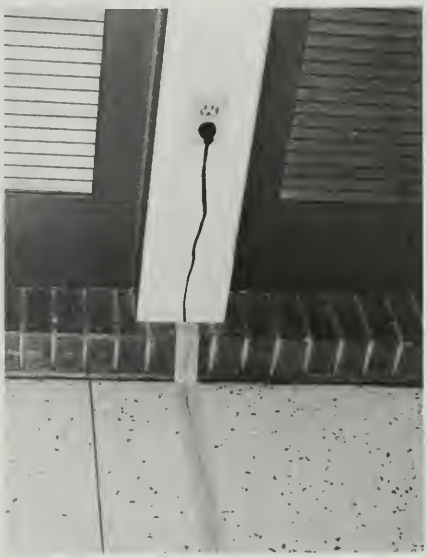



*Ideal public-address setup for banquet hall looks something like this, with wall and ceiling speakers aimed well away from mikes. Properly set up and tested ahead of time, PA system should give no trouble when it's called on to deliver its all-important goods.*

happy solution a contrived ending. But now let's put the shoe on the other foot in a situation where any contriving may be strictly up to you. Let's say that, well in advance, your lodge had the good sense to make you their sound liaison man with the hotel. So you approach the manager via the public relations route and explain that the lodge has asked you to offer cooperation in meeting the sound needs of the meeting. Since this has probably never happened before, you have thereby earned a good question-and-answer session with one of his aides, perhaps the hotel engineer.

For your particular table and seating arrangements, where will the mikes be plugged in and what types are available? Where is the amplifier located and what are the normal ranges of the gain and tone pots? Can the mikes be seen from the amplifier

*Two directional mikes in Shure's Unidyne series. Left, Model 55S accepts cable plug-in connector on threaded collar; right, Model 545 has cable-mounted connector.*



*Leaving exposed cables and cords around banquet hall is asking for trouble. Best bet is to tape down all floor cables—those for microphones and speakers as well as all AC line cords—with painters' masking tape to avoid possible accidents.*

location? Where are the speakers to be located? Sometimes they are fixed in place, with some or all hidden in the ceiling.

What is the range of movement of any speakers that can be relocated if necessary to reduce feedback or fill in dead spots? And you ask to have the hotel paging system disconnected so that the switchboard operator can't come booming in over the climax of the guest speaker's best joke.

*Dress rehearsal.* You then diplomatically ask to try out the system with the types of mikes you want, placed where you want them. You ask for the directional type as feedback insurance, and this includes the audience traveling mike. With the master-gain and tone-control pots set at mid-range, you note down the position of each mike pot for maximum volume before feedback occurs.

All mikes are *on* for this test. If this volume is adequate in the empty room, you figure there should be no howl problem with a full house, since an audience absorbs sound. Any additional volume needed then is obtained by carefully inching up the master gain without disturbing the individual mike pots.

Listening critically, you note the absence of hum but detect some crackling when using one of the mikes. With the hotel man nodding assent, you note that the cable is snug in the mike head and that tapping the instrument causes no crackling. But flexing the cable as you walk toward its wall receptacle, you suddenly come to a point that really makes the system bark.

Too many hotel dish carts have been rolled over that cable, and your guide notes the need for a new one. The other table mike seems to cause pops, particularly if you get too close to it. Sadly you agree replacement is in order.

Trying out the traveling audience mike, you notice it causes howling when carried under any of the ceiling speakers. You learn that, unlike some installations, these speakers have no cut-off switches. This means that you'll want the mike man practically pushing the microphone into the users' faces to permit minimum gain setting to discourage feedback. And this reminds you to have someone assigned to that mike, and also an operator at the amplifier you'll maintain liaison with as the sound scout. Here you recall there may be a union and you make your arrangements with the hotel man accordingly.

*A show for sure.* And now you foresightedly consider what to do if trouble occurs on the big night. If the hotel furnishes an operator (this is unlikely in small establishments), you're in his hands. If the lodge is graciously permitted to handle the amplifier, any fast fix needed is likely to be your baby—if only because the emphasis is on fast.

If the system conks out completely, maybe some wise guy pulled the AC plug or a mike connector. Or maybe the amplifier innocently blew a fuse. If the fuse isn't plainly visible, you ask the hotel man for its location, along with a spare fuse which you tape to the amplifier. The fuse has been known to be hidden in the body of the AC plug.

And what if that old devil Hum should loudly assert his dominion? You'll promptly try reversing the AC plug in the wall socket, and make sure the pot on any unused channel including a phono input—is all the way *off*. You'll make sure any grounding wire to the amplifier chassis is tight. If these tricks don't work and the hum is bad enough to warrant the interruption, you'll kill each mike pot in succession. If this points up a bad channel, you'll plug into a spare channel if any, or commandeer the traveling mike. Or you'll turn down the gain on the offending channel and ask the speaker to talk closer to the mike to improve the signal-to-hum ratio. But if the trouble is not in one of the mike channels, you'll rap the amplifier smartly—just in case—and/or turn down the tone control to minimum bass and ride out the storm.

And on banquet night, you'll firmly tape all exposed cables to the floor and all table mike cables to the table legs, using 3-inch painter's masking tape. Thus do you prevent mikes, members, and MCs from becoming accident statistics. And thus does your overall planning assure the Royal Grand Potentate will truly lay 'em in the aisles—because the sound system will lay no eggs.

*See also:* ELECTRONICS; MICROPHONES; SCIENCE PROJECTS.

➤ *Individual ceiling speakers in some halls are equipped with cut-off switches to control feedback. Reached with what hotel employees refer to as skyhooks, switches can save the day for the PA operator.*

# What to Do about Quicksand

**Once cloaked in mystery, this hikers' booby trap is actually a simple natural phenomenon that can be handled by anyone who keeps his head**

QUICKSAND IS A WORD of sinister connotations. It is nature's own booby-trap and one of man's oldest and weirdest nightmares. Your chances of contact with it sometime during your life, even in this modern age, are high.

Quicksand is to be found in virtually every state of the Union and not always in the backwoods. For instance, it has been found in such heavily populated areas as Long Island, N.Y., and in such unlikely places as the Colorado Rockies.

Not always is it found on the surface, either. The new $100 million Chase Manhattan Bank building in New York City, for instance, rests partly on quicksand which appeared when the foundation hole had been excavated to a depth of 60 feet.

Quicksand can be dealt with. It is not, as many have been led to believe, inescapable. At the same time, there are many who have tried to escape it and failed. Most victims died in it because of one thing; they became frantic and many succumbed to shock, not quicksand.

The one thing most important to remember, should you become involved in quicksand, is this: If you keep your head, you will float in it even more readily than you would in water. Your body will only sink into it until it displaces its own weight—then it will float.

The late geologist Gerard H. Matthes, an expert on quicksand for the U.S. Geological Survey, frequently used to say, "Anybody who ever walks off the pavement should learn about quicksand." He himself was walking proof that man could escape from the horrors of this phenomenon, having once been trapped for eight hours in a quicksand bog in Colorado. Although alone at the time, he managed slowly to pull himself free, but those hours were an ordeal he never forgot.

Normally quicksand is found in low-lying regions, usually along streams. In most cases, it will be found on a flat surface, and may look as stable as the Rock of Gibraltar. When you begin to walk on it, though, you'll suddenly realize the difference, as did two young college students while hiking through the Big Thicket in East Texas, a couple of years ago.

Skirting the edges of a stagnant slough, the student in the lead, suddenly shouted: "I'm in trouble! Don't come any closer!" The soil had crumbled under his feet and already he was floundering in ankle deep ooze. When he tried to yank his feet clear, they only sank deeper and within seconds, he was up to his knees. He panicked.

The other student, instead of plunging in to help his friend, coolly cut a small sapling nearby with his hatchet and raced back to the edge of the quicksand.

Directing the trapped student to drop his back pack, which was pulling him down, he pushed the tree toward the victim. "Now fall back on the branches," he directed. With his weight supported by the tree, it took him more than an hour to free his submerged legs from the sucking mass. But he survived a harrowing and almost fatal experience.

There's only one protection against quicksand. Learn all you can about it first of all, and secondly, learn what to do in

**rabbeting:** see woodworking
**race car bed:** see beds

case you're entrapped in its clutches. If you like to hike, boat, swim, camp, hunt or fish, you're more likely to encounter quicksand. But if you never do any of these things, you still may come into contact with it.

An example of what could happen did in the late 1800s after a flash flood tore out a wooden trestle on the Kansas Pacific Railroad east of Denver on Kiowa Creek. A train plunged into the churning torrent. When the water had run out of the normally dry creekbed, giant railroad cranes retrieved the cars, but the engine was missing. Workmen probed the sands of the Kiowa Creek to a depth of 50 feet over a period of weeks, but no trace of the locomotive was found. The 200-ton machine had simply been swallowed up in a quicksand bog.

Quicksand is indeed a weird phenomenon. Almost nothing was known about it prior to World War II and still information is sketchy and controversial. Few authorities agree on any one question about the subject. It may play an even more important role in the structure of the earth than we suspect.

During World War II, soldiers in both the European and Pacific theaters were confronted by quicksand in many instances. Equipment and lives were lost. It became such a problem that numerous scientific studies were conducted. Among the foremost was one by the late Dr. Ernest "Rock" Smith. He spent days studying a quicksand bed in a farm pasture not far from town. The bed was near a small stream. When he threw a rock in it, the sand quivered like gelatin and seemed almost alive.

Smith scooped up a bucketful and examined it under a microscope. The grains turned out to be the same as any other sand grains—some were round, but most were jagged. For some time previously it had been theorized that quicksand was caused by round grains of sand that could not congeal to one another. But Smith's research eliminated that theory. And once in the bucket, the sand was no longer quick in Smith's laboratory.

Back in the pasture, Smith talked to the owner of the farm who said: "Funny thing about that stuff. Sometimes it's quick, sometimes it's firm. Come back in August and you'll be able to square dance on it."

Dr. Smith later built an experimental device in which water could be made to flow through sand in various ways. When the water was forced into the sand from the bottom, the sand became quick. From any other direction, it was solid. Smith had solved the question of what made quicksand quick, but he had not solved the problem of how to escape it.

Here is some advice for those who often venture into the wilds:

Carry a long stick with you and if you suspect there's quicksand ahead, probe it with the stick before walking on it.

If you're already stepping in it, try to run. Some kinds of quicksand are just firm enough to allow this, if you act fast enough.

If you sink too fast to run, throw yourself flat on your back.

Don't try to hold your arms up in the air, but instead, spread them at a 90-degree angle from your body. Let them rest on the quicksand surface, but don't press down with them.

Get rid of any extra weight such as a gun belt, back pack, etc.

Shout for help. While it's coming, lie still.

If help does not come, slowly roll your way to firm ground, or turn onto your stomach and do a slow breast stroke.

Make all movements slow and deliberate. If you move fast, the movement will create suction pockets in the muck and these could pull your head under.

The trend today is toward the great outdoors, but with this trend comes the extended hazard of quicksand. It is not to be feared, but certainly respected. And the more you know about it, the greater your chances of survival. B.T.

# How to Build a Mini-hydrofoil

**A four-horse inboard propels this craft at speeds up to 16 miles an hour, but it's safe enough for an eight-year-old to operate**

THIS BOAT IS A MINI inboard hydro that's powered with a 4 hp air-cooled engine. Its top speed is about 16 mph with a 100-pound teenager aboard. It features a "dead man's" throttle that shuts the motor off when the driver lets go of the throttle, so there's no danger if the operator falls off the boat. Safe enough for an eight-year-old, it's a great little boat for the young to start out on. Use is limited to well-protected waters, of course.

Light weight is important to this hull, so lightening holes must be cut in some structural members and all planking is of ⅛-inch plywood except for the ¼-inch plywood sponson planking. Framing is of spruce or cedar, in ½-inch and ⅓-inch thicknesses. If you cannot get ½-inch stock, buy ¾-inch lumber and use a planer jointer to bring it down to size. Your lumber yard will do it for a modest fee. Motor mounts are cut from 2 x 4-inch fir.

Start construction by making up the transom and ribs. The transom is cut from solid ½-inch cedar stock, and is carefully notched for the keel and battens. Use a circle saw to cut out the lightening holes. Cut ⅛-inch plywood to the same shape as the transom, but do not notch it or cut holes. Coat mating surfaces with glue, and nail the plywood in place with ⅝-inch #16 bronze boat nails.

Next make up ribs 3 and 4, which are identical. Note that each has a full-width bottom member, and two short upper members. Use ⅛-inch plywood gussets at the outer ends, glued and nailed in place, to give the ribs their full shape.

Rib 2 is quite important, as it not only establishes the full width of the hydro, but makes up the back of the sponsons as well. The main structural unit is cut from solid ½-inch stock, and is notched for keel and battens. A large lightening hole is cut at each end. Cut a ⅛-inch plywood panel to shape for each end of the rib, and glue and nail in place on the back of the rib. Note that ¾-inch square stock must be glued and nailed to the back side of these panels, as shown by the dotted lines. The lower block takes the fastenings for the air trap member, and the hull sides fasten to the upper, slanted block.

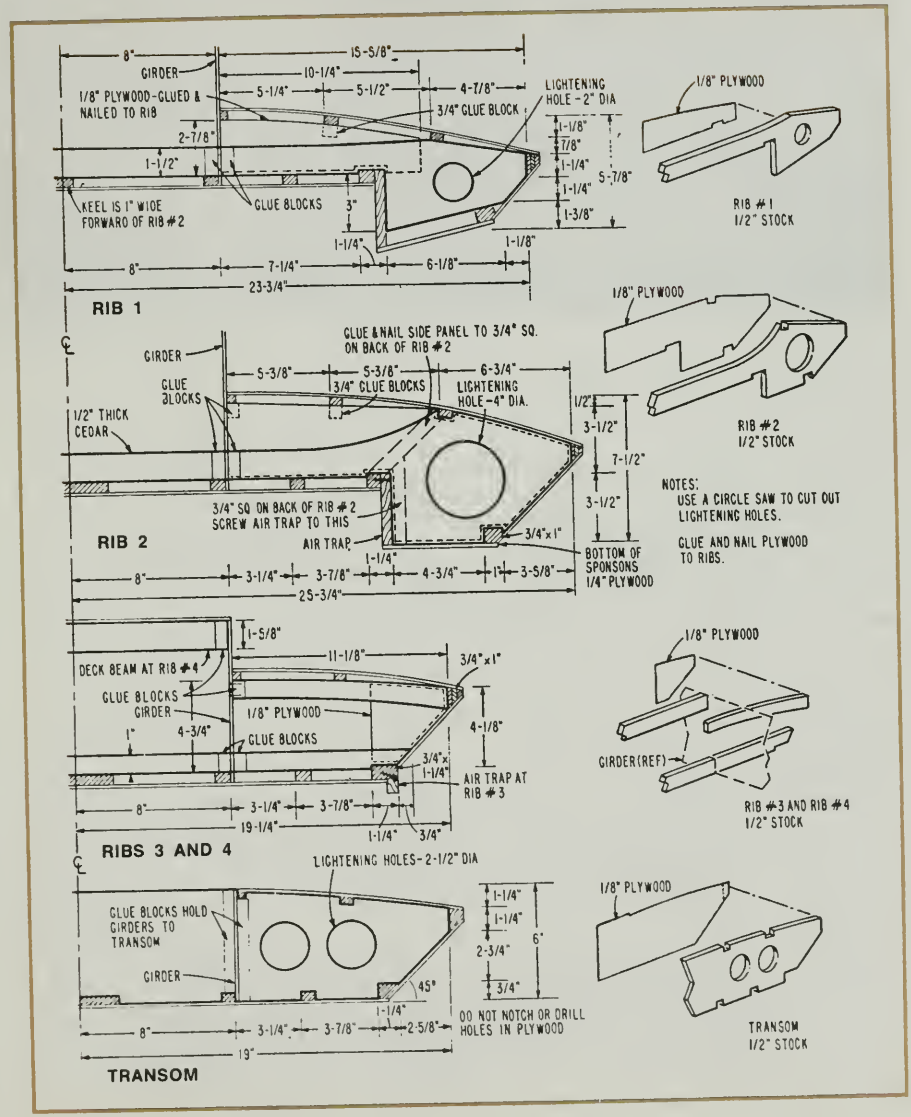
Finally, make up rib 1, also of ½-inch

**rack, luggage:** see car top
**rack, lumber:** see lumber
**rack, spice:** see spice racks
**rack, wine:** see plastics, fabricating

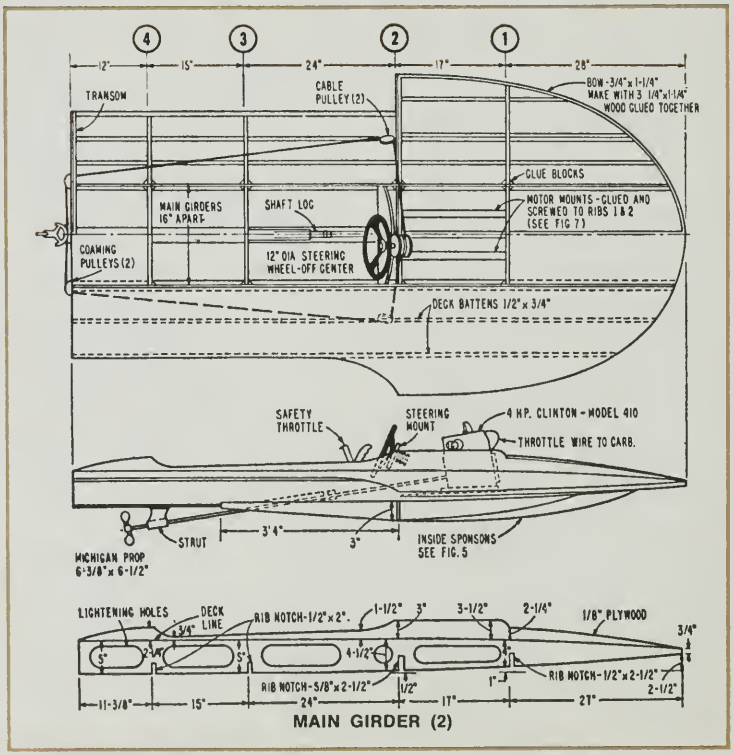
stock, with a ⅛-inch plywood panel glued and nailed in place so the deck battens can be fastened to it.

The two main girders are the heart of the craft, so take special care with them. They must be exactly the same size and

*Transom and four ribs are constructed first. Use a circle saw to cut out the lightening holes.*


RIB 1
GIRDER
1/8" PLYWOOD-GLUED & NAILED TO RIB
KEEL IS 1" WIDE FORWARD OF RIB #2
GLUE BLOCKS
3/4" GLUE BLOCK
LIGHTENING HOLE - 2" DIA
1/8" PLYWOOD
RIB #1 1/2" STOCK
RIB 2
GLUE & NAIL SIDE PANEL TO 3/4" SQ. ON BACK OF RIB #2
GLUE BLOCKS
1/2" THICK CEDAR
3/4" GLUE BLOCKS
LIGHTENING HOLE-4" DIA.
3/4" SQ ON BACK OF RIB #2 SCREW AIR TRAP TO THIS
AIR TRAP
BOTTOM OF SPONSONS 1/4" PLYWOOD
RIB #2 1/2" STOCK
NOTES:
USE A CIRCLE SAW TO CUT OUT LIGHTENING HOLES.
GLUE AND NAIL PLYWOOD TO RIBS.
RIBS 3 AND 4
DECK BEAM AT RIB #4
GLUE BLOCKS
GIRDER
1/8" PLYWOOD
AIR TRAP AT RIB #3
GIRDER (REF)
RIB #3 AND RIB #4 1/2" STOCK
TRANSOM
LIGHTENING HOLES-2-1/2" DIA
GLUE BLOCKS HOLD GIRDERS TO TRANSOM
GIRDER
45°
DO NOT NOTCH OR DRILL HOLES IN PLYWOOD
TRANSOM 1/2" STOCK

*Here framing is complete except for sponson chines. Clearly seen are 2x4's that make up the building jig. Heavy pine clamps hold the bow.*



*Here the framework is right side up with shaft log and steering panel installed, as well as the deck beams and battens. Give interior of hull three coats of paint or varnish before you fasten the deck panel in place.*

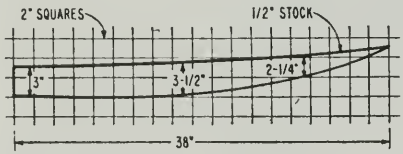
shape, so it's best to clamp them together to trim them to shape, and to cut the notches for ribs. Shape and dimensions are shown in the drawing.

Now set up your building jig. This is two 8-foot lengths of 2 x 4s, securely fastened to provide a comfortable working height. They can be set up on sawhorses or a workbench, for example. The two lengths should be exactly parallel, with a 16-inch distance between their outer edges.

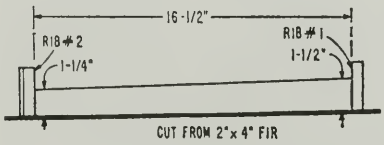
Clamp the two girders to the outside of the jig, as shown in the photo. Adjust them carefully so they are at the same height, and the rib notches are in proper alignment. Fasten the transom to the girders with ¾-inch square glue blocks on the outside ends of the girders. Slip each rib into its proper notches, and fasten it with triangular glue blocks. Nail transom and ribs in place with 1-inch wire nails.

Make up the keel of ½-inch stock. Note that it is 4 inches wide back of rib 2, in order to accept the shaft log. Forward of rib 2 it is only 1-inch wide. Set it into its notches on the transom, use glue on mating surfaces, and fasten with two 1-inch flat head wood screws at each joint. Be sure to countersink for the heads, and drill pilot holes.

Install the bottom battens. The center battens extend forward of rib 1. It is not necessary that they extend all the way forward to the bow. The two inner battens fasten to the main girders, as well as to the ribs. Fasten with glue and nails at each joint.




**INSIDE SPONSON (2)**




**ENGINE MOUNT (2)**

The bow piece that bends around the front of the boat and along the sides of the sponsons is made up of three pieces of ¼ x 1¼-inch cedar. Glue is applied to them, and they are bent as a unit, while the glue is wet, around the frame and are fastened to ribs, girders, and battens. Use plenty of clamps until the glue is dry.

Use solid ½-inch stock for the inside sponson pieces. Clamp the two pieces together and trim to exactly the same shape before installing them with glue and nails to outer battens (chines) and to ribs 1 and 2.

Use ¾ x 1-inch stock for the outside sponson battens. These take a considerable bend near the bow. Soak the front section of these in hot water so they will take the bend with ease. They are glued and nailed to ribs 1 and 2, and to the bow piece.

Carefully fair all the framework so plywood bottom side, and sponson planking will lie flush against it. Sponson members can be faired with a hand plane, then trued with a file, or with coarse sandpaper on a sanding block.

*Steering, dead man's throttle and engine installations are seen in this photo. A gentle curve in throttle cabin allows it to operate without binding. Engine is a 4-horse model.*

Plank the two sides first, behind the sponsons. Clamp a section of ⅛-inch plywood in place, trace the outline on it, remove it, and cut the panel to shape, but slightly oversize. Coat mating surfaces with glue, and nail each panel in place with ⅝-inch #16 bronze nails, spaced about 2 inches apart. Trim the panels flush with the framework. The two sponson chine panels are made up and installed in the same manner. Note that on each sponson the ¼-inch bottom panel will overlap these side panels behind rib 1, and will butt against the edge of the side panel forward of this rib.

Now make up the bottom panel. This is a single length of ⅛-inch plywood, 32 inches wide (it can be made up of two shorter lengths, with a butt joint, if necessary). Clamp it in place, mark the outline of the outer edge of the bow, and from inside the boat, mark the outline of all battens, keel, etc. Remove the panel and trim the bow to shape. Use a small bit—1/16-inch is fine—and drill pilot holes for nails in the spaces marked for battens and other members.

Check your framework carefully, to make sure it is squared and true. Coat mating surfaces with glue, clamp the panel back in place, and nail the panel to the framework through the previously drilled holes. Have someone hold a weight under the framework where you are working so the nails will seat solidly.

Now the shaft hole can be drilled. Screw a block of wood in place temporarily on the keel inside the boat, where the drill will come through. This will prevent the keel member from splintering when you drill. Use a scrap of plywood to make up a template that gives you the proper angle,

**MATERIALS LIST**

| Quantity | Size and Description | Purpose |
|---|---|---|
| 3 | 1/8" 4'x8' plywood | bottom, sides, deck planking |
| 1 | 1/4" 4'x8' plywood | sponson bottoms |
| 4 | 1/2" 12"x8' cedar or spruce | framing |
| 1 | 3/4" 1 1/2"x10' cedar or spruce | bow piece |
| as needed | #16 5/8" bronze boat nails | |
| as needed | #14 1 1/4" bronze boat nails | |

**NOTE:** Also need marine grade plastic resin glue, paint or varnish, engine, propeller, safety throttle, throttle wire, coaming pulleys, cable pulleys, steering cable, steering wheel, lifting handle, shaft log, strut, propeller shaft and rudder assembly.

and nail it in place lightly on the keel alongside the center line on the outside of the hull. Use an auger with a 7/8-inch bit, after notching the keel with a wood chisel to allow the drill tip to get a good bite. Be sure to keep the bit aligned with your template.

Remove the template, unclamp the girders from the building jig, and turn the boat upright. Remove the temporary block from inside on the keel, and install the shaft log; make sure it is aligned with the hole.

The steering mount is a 16-inch length of 3/4-inch stock, 4 inches wide. Glue and nail it in place at an angle between the girders, above rib 2. The hole for the wheel shaft should be slightly offside to the right. Install the deck battens in the same manner as the bottom battens and add the steering wheel pulleys. These must be bolted—not screwed—to rib 2. Give the entire hull interior three good coats of paint or varnish, as desired.

When the interior is dry, deck panels can be cut from 1/8-inch plywood, and glued and nailed in place in the same manner as the bottom and side panels.

Turn your boat upside down again, and fasten the airtraps in place with screws through the planking into the framing. Install the shaft and strut; also install a sponson fin on the back of the left hand sponson, if you plan on making any tight turns. For general use, this should not be needed. Install the rudder mount and the transom pulleys.

Cut the two mounting blocks for the engine to shape. These are glued and screwed in place between ribs 1 and 2.

With the boat upright, the engine can be installed. It is the four-h.p. Clinton, Model 110. Use care to get it set at the proper angle to the shaft, and bolt it to the engine mounts. A standard coupling can be used to attach the motor to the shaft. This will give you a straight drive, with no neutral or reverse, but these are not necessary on such a small boat. Mount the dead man's throttle on the left hand girder and attach its control wire to the engine. Rig the steering wheel and tiller lines.

Now the exterior of the boat can be finished with paint or varnish, as desired. Use at least three coats; allow each to dry thoroughly, and sand lightly before applying the next coat. H.K.

*See also:* BOAT BUILDING; BOAT BUILDING PROJECTS; RUNABOUTS; WOOD BENDING.

**WHERE TO FIND IT**

The safety throttle, throttle wire, coaming pulleys, cable pulleys, steering cable, steering wheel, lifting handle, shaft log, strut, propeller shaft and rudder assembly can be obtained from Williams Mfg. Co., 6450 Olympic, Bremerton, Wash. 98310. Write to them for information.

# How to Use a Radial Arm Saw

**This is one of the most versatile power tools you can acquire, although getting maximum use out of it requires a thorough knowledge of its capabilities**

One of the most versatile power tools you can install in your workshop is a radial arm saw. In addition to making any cut a table saw can, it can also be pressed into service as a borer, router, shaper, disk or drum sander, or grinder—even as a power source for flexible shaft tools.

The radial saw yields to the table saw on one count. It cannot make cuts in the center of very wide stock. But, when cutting most lumber, the radial saw is more convenient than the table saw.

Essentially, the radial saw is a motor with an arbor carrying a circular saw blade. The motor is slung by a yoke beneath an arm. The saw and yoke slide on the arm back and forth over the work. The arm is mounted on a pivot.

As you face the saw, the arm is pointed at you. The work table has a fence at the back that runs crossways from one side of the table to the other. The saw, at the start position, is on the other side of the fence at the far end of the arm.

To make a simple crosscut, hold the work against the fence with your left hand, keeping it well out of the path of the saw, grasp the saw by the handle with your right hand and pull it toward you, cutting through the work. Push it back and the operation is completed.

The versatility of the saw lies in the fact that the position of the arm and of the saw and motor unit are adjustable.

The simple 90-degree crosscut, for example, was made with the saw riding through the work perpendicular to the fence. But, the arm can swing on the pivot. If you swing the arm to the left

**radiator, auto:** see cooling systems, auto
**radiators:** see heating systems, home

or right and lock it in place and make a cut, the result is a miter. Most saws have a detent mechanism that makes it easy to stop the arm at most of the common miter angles.

Instead of swinging the arm, you can leave it at 90 degrees and tilt the saw blade itself to almost any angle. The result of a cut made this way is a bevel or chamfer, depending on where the work is held.

If you both swing the arm and tilt the blade the result is a compound miter cut, as might be used in cabinet work such as making picture frames.

Safety note: when making any cut with a radial arm saw always keep your hands away from the saw blade. If you are working with small material, clamp or tack it to the table.

Ripping is done with the saw and motor swiveled so the blade is parallel to the fence. Slide the saw in this position along the arm until it is the correct distance from the fence. You can use the rip gauge on the side of the arm to make this adjustment.

When ripping, always feed the stock against the rotation of the blade. The bottom portion of the blade should be moving toward you and the handle of the saw should be on the side away from you.

Never rip without engaging the anti-kickback fingers. Every saw has this device. Usually these fingers are at the end of an arm that can be adjusted upward or downward to accommodate different thicknesses of stock. Make sure these fingers extend about ⅛-inch below the surface of the stock before you start to rip.

As you feed the work past the saw and under the fingers, the fingers flip up and rest on the surface. If the blade kicks the stock back toward you, the ends of the fingers dig into the wood like ratchets and prevent the stock from moving.

*Making a simple crosscut with a radial arm saw. Note how left hand holding stock against fence is kept well away from saw blade.*

*Mitering illustrates convenience of radial saw. Instead of holding long piece of stock at an angle and moving it past a blade, as with a table saw, the stock is simply held against the fence of the radial saw and the blade is passed through it at the proper angle. Miter angle is set by swinging the arm.*

Feed the work to the saw evenly, but don't force it. Also, remember to keep your hands clear of the saw blade. When working with narrow material, use a wooden pusher near the blade, rather than your hand.

In addition to ripping square cuts, the saw can be tilted while in the ripping position to make long bevels or chamfers. Do not attempt to rip a chamfer or bevel on very narrow stock. Make your cut on a wider piece, then use a vertical rip to cut it to the correct width.

The same techniques can be used to cut grooves and dadoes. Just raise the saw blade the correct distance from the table to provide the desired depth of cut and proceed as you would for an ordinary crosscut, miter, bevel or rip. Or the saw can be rotated so the blade is parallel to the table for cutting kerfs and rabbets in the edge of thin stock.

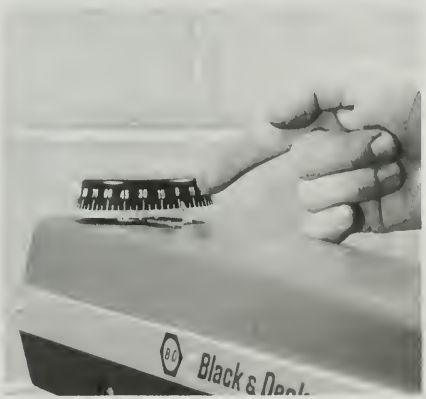
Every radial saw has a handle that the user rotates to raise and lower the arm—and with it the motor and saw. Usually, the handle or crank is calibrated so that the amount of rotation equals a given amount of travel up or down—⅛-inch per turn, for example.

You can use a dado head or simply make a series of parallel cuts with a saw blade to remove material. When using a dado cutter, remember that the saw must remove much more material per inch of travel than it does with an ordinary blade, so feed the work more slowly.

Without a saw blade, the machine can be thought of simply as a source of rotary power than can be set at almost any angle. The motor can be used to turn sanding drums or disks, twist drills, shapers, router bits and abrasive grinding wheels.

To sand a miter with precision, for example, set the machine up in the same way as for sawing, but use a sanding disk instead of a saw blade. Then, pass the sanding disk across the miter cut as if you were sawing it. This will provide an accurate flat surface with no risk of removing too much material at the edges, as you could with a sanding block or a hand-held power sander.

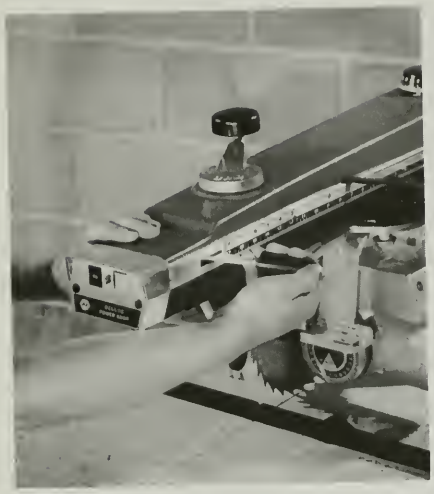
The machine can be used as a drill press by swiveling the motor so the arbor points at the fence and chucking on a drill bit.



*Miter indicator for this saw is on top of arm. It indicates the angle at which the arm is swung from perpendicular, hence the angle of the miter.*

*Pulling yoke clamp handle on this radial arm saw model frees yoke so motor can swivel about its vertical axis to any desired angle. Pushing yoke handle locks the unit in position.*

*How to Use a Radial Arm Saw*



*Pulling on radial saw arm clamp, as operator is doing, permits the arm to be swung to any position left or right for miter or angle cuts. Crank on top of arm is to raise or lower saw.*

*Cutting lattice work with a dado head. Depth of cut is set at half the thickness of the stock and diagonal dado cuts are made on each side.*

Instead of boring vertically, the radial saw bores horizontally. If you need to drill angled holes, simply swing the arm to either side to the desired angle, as you would for a miter cut.

Generally, the saw motor is tilted so the arbor is vertical when it is used to turn a shaper, although varying the angle can be used to obtain a variety of profiles from the same set of shaper blades.

When the radial arm saw is used with a grinding wheel, set the motor in the same position as for the basic crosscut with a saw blade and construct a rest for the work out of a few pieces of scrap. Use this rig just as you would an ordinary grinder to sharpen tools and the like.

To achieve the accuracy that a radial saw is capable of, check the adjustments when you install and periodically after that. All the key assemblies of a radial saw are adjustable, although the way these adjustments are made vary from saw to saw. See your owner's manual to see how each is made.

The table top and the radial arm must be on parallel planes. There are two ways to check this. The first is to remove the blade and the blade guard and tilt the motor so the arbor is vertical. Lower the motor until the tip of the arbor barely touches the table. Then, bend over so your eye is at table level and move the saw around the table. Watch to see that the arbor is barely touching the table at all points. If there is space between the arbor and table, the table is too low at that point. If the arbor presses against the table hard, the table is too high.

The second method is to make a similar test with the saw blade and guard in place and the blade vertical. Place a flat piece of plywood on the table and lower the saw to make a skimming cut. Move the saw over the flat plywood and observe the depth of cut. It should be the same skimming depth at all positions.

**RADIAL ARM SAW TROUBLE-SHOOTING CHART**

| Condition | Possible Cause | Remedy |
|---|---|---|
| **Saw will not make a square cross cut or a good 45° miter cut** | 1. Arm is not perpendicular to guide fence<br>2. Arm has excessive play at end<br>3. Column is loose in base<br>4. Too much play between arm and column<br>5. Roller head too loose in arm<br>6. Yoke too loose when clamped to roller head<br>7. Sawdust between lumber and guide fence<br>8. Table not parallel with arm<br>9. Guide fence not straight<br>10. Rear edge of fixed board not straight | 1. Adjust crosscut travel with guide fence<br>2. Tighten adjusting screws<br>3. Make proper adjustment<br>4. Make proper adjustment<br>5. Adjust roller head correctly<br>6. Adjust yoke clamp handle<br>7. Keep table top clean<br>8. Make proper adjustment<br>9. Replace fence<br>10. Sand or replace |
| **Lumber has a tendency to walk away from fence when ripping or ploughing** | 1. Saw blade is not parallel with fence<br>2. Arm not perpendicular to guide fence<br>3. Dull blade or cutters<br>4. Fence not straight<br>5. Feed rate too fast<br>6. Wrong blade<br>7. Column too loose in base<br>8. Too much play between arm and column<br>9. Roller head too loose in arm<br>10. Yoke loose when clamped to roller head<br>11. Sawdust between lumber and fence | 1. Make heel adjustment<br>2. Adjust crosscut travel with guide fence<br>3. Sharpen or replace blade<br>4. Replace fence<br>5. Slow feed rate<br>6. Use correct blade<br>7. Make proper adjustment<br>8. Make proper adjustment<br>9. Make proper adjustment<br>10. Adjust yoke clamp handle<br>11. Keep table top clean |
| **Saw stalls when ripping or ploughing** | 1. Saw blade is not parallel with fence<br>2. Arm not perpendicular to guide fence<br>3. Dull blade or cutters<br>4. Fence not straight<br>5. Feed rate too fast<br>6. Wrong blade<br>7. Column too loose in base<br>8. Too much play between arm and column<br>9. Roller head too loose in arm<br>10. Yoke loose when clamped to roller head<br>11. Sawdust between lumber and fence | 1. Make heel adjustment<br>2. Adjust crosscut travel with guide fence<br>3. Sharpen or replace blade<br>4. Replace fence<br>5. Slow feed rate<br>6. Use correct blade<br>7. Make proper adjustment<br>8. Make proper adjustment<br>9. Make proper adjustment<br>10. Make proper adjustment<br>11. Keep table top clean |
| **Saw blade scores lumber, not giving a good finished cut** | 1. Saw blade is heeling<br>2. Column too loose in base<br>3. Too much play between arm and column.<br>4. Roller head loose in arm<br>5. Yoke too loose when clamped to roller head<br>6. Bent blade or dull<br>7. Not feeding saw properly<br>8. Using improper blade for finish cut desired | 1. Make heel adjustment<br>2. Make proper adjustment<br>3. Make proper adjustment<br>4. Make proper adjustment<br>5. Make proper adjustment<br>6. Replace blade<br>7. Draw saw blade across lumber with a slow and steady pull<br>8. Change blade |

| Condition | Possible Cause | Remedy |
|---|---|---|
| **Saw blade or dado blades tend to push lumber to one side when cross cutting** | 1. Saw blade is heeling<br>2. Column too loose in base<br>3. Too much play between arm and column<br>4. Roller head too loose in arm<br>5. Yoke too loose when clamped to roller head<br>6. Fence not straight<br>7. Dull blade or cutters | 1. Make heel adjustment<br>2. Make proper adjustment<br>3. Make proper adjustment<br>4. Make proper adjustment<br>5. Make proper adjustment<br>6. Replace fence<br>7. Replace or sharpen blade |
| **Cut depth varies from one end of stock to the other** | 1. Table top not parallel with arm<br>2. Column too loose in base<br>3. Too much play between arm and column | 1. Adjust table top parallel with arm<br>2. Make proper adjustment<br>3. Make proper adjustment |
| **45° bevel cut not accurate** | 1. Saw blade not perpendicular to table top<br>2. Column too loose in base<br>3. Too much play between arm and column<br>4. Roller head too loose in arm<br>5. Yoke too loose when clamped to roller head<br>6. Bevel clamp handle loose<br>7. Table top not parallel with arm | 1. Make saw blade adjustment<br>2. Make proper adjustment<br>3. Make proper adjustment<br>4. Make proper adjustment<br>5. Make proper adjustment<br>6. Make proper adjustment<br>7. Make proper adjustment |
| **Saw tends to advance over lumber too fast** | 1. Roller head bearings not properly adjusted<br>2. Dull blade<br>3. Not feeding saw properly | 1. Adjust roller head bearing to arm<br>2. Replace or sharpen blade<br>3. Draw saw blade across lumber with a slow and steady pull |
| **Saw does not traverse smoothly in tracks** | 1. Dirty tracks<br>2. Bad bearing | 1. Clean<br>2. Replace bearing |
| **Miter scale not accurate at various miter angles** | 1. Scale pointer not properly adjusted | 1. Adjust scale pointer |
| **Elevating handle slips when elevating or lowering saw** | 1. Belt tension not sufficient<br>2. Setscrew in elevating arm loose<br>3. Base not adjusted properly | 1. Adjust belt tension<br>2. Tighten setscrew<br>3. Adjust base to column |
| **Clamping force not sufficient at miter angles other than 45°** | 1. Arm clamp out of adjustment | 1. Adjust arm clamp |
| **Clamping force not sufficient at bevel angles other than 45°** | 1. Bevel clamp handle too loose | 1. Adjust bevel clamp handle |

To make sure the arm is precisely perpendicular to the fence when it is in the 90-degree position, mark a 90-degree cut on a wide piece of stock with a square. If the arm is properly adjusted, the blade will follow the line from the start of the cut to the end.

Also use a square to determine whether the blade is perpendicular to the table. Remove the blade guard and place one leg of the square on the table and the other against the saw blade. Make sure the square is in the gulleys of the saw blade between the set teeth.

Test for heeling by making a crosscut in a wide piece of stock about 2 inches thick

and looking for pronounced radial marks left on the cut by the back teeth of the saw. If you find them, it means that the saw is slightly swiveled in relation to the arm and the back teeth are not following the same path as the front teeth through the cut. You can also feel heeling during cutting. The blade seems to drag, and you will notice that cut edges are rougher than they ought to be. F.C.

*See also:* HOPPERS; POWER TOOLS; TABLE SAW; TOOL TECHNIQUES; WOODWORKING.

**SAW MOTOR TROUBLE-SHOOTING CHART**

| Condition | Possible Cause | Remedy |
|---|---|---|
| **Motor will not run** | 1. Protector open; circuit broken | 1. Reset protector by pushing on red button (indicated by audible click) |
| | 2. Low voltage | 2. Check power line for proper voltage |
| **Motor will not run and fuses "BLOW"** | 1. Short circuit in line cord or plug | 1. Inspect line cord and plug for damaged insulation and shorted wires |
| | 2. Short circuit in junction box, or loose connections | 2. Inspect all terminals in motor junction box for loose or shorted connections |
| **Motor fails to develop full power. (Power output of motor decreases rapidly with decrease in voltage at motor terminals)** | 1. Power line overloaded with lights, appliances and other motors | 1. Reduce line load |
| | 2. Undersize wires or circuit too long | 2. Increase wire sizes, or reduce length of wiring |
| | 3. General overloading of power company's facilities. (In many sections of the country, demand for electrical power exceeds the capacity of existing generating and distribution systems) | 3. Request a voltage check from the power company |
| | 4. Incorrect fuses in power line | 4. Install correct fuses |
| **Motor starts slowly or fails to come up to full speed** | 1. Low voltage—will not trip starting relay | 1. Correct low voltage condition |
| | 2. Starting relay not operating | 2. Replace relay |
| **Motor overheats** | 1. Motor overloaded | 1. Correct overload condition |
| | 2. Improper cooling. (Air circulation restricted through motor due to sawdust, etc.) | 2. Clean out sawdust to provide normal air circulation through motor |
| **Starting relay in motor will not operate** | 1. Burned relay contacts (due to extended hold-in periods caused by low line voltage, etc.) | 1. Replace relay and check line voltage |
| | 2. Open relay coil | 2. Replace relay |
| | 3. Loose or broken connections in motor terminal box | 3. Check and repair wiring |
| **Motor stalls (resulting in blown fuses or tripped circuit breakers)** | 1. Starting relay not operating | 1. Replace relay |
| | 2. Voltage too low to permit motor to reach operating speed | 2. Correct the low line voltage condition |
| | 3. Fuses or circuit breakers do not have sufficient capacity | 3. Replace fuses or circuit breakers with proper capacity units |
| **Frequent opening of fuses or circuit breakers** | 1. Motor overloaded | 1. Reduce motor load |
| | 2. Fuses or circuit breakers do not have sufficient capacity | 2. Replace fuses or circuit breakers |
| | 3. Starting relay not operating (motor does not reach normal speed) | 3. Replace relay |

# Boring and Routing with a Radial Arm Saw

**Your radial arm saw's ability to slide, swivel and tilt make it adaptable as a router and as a horizontal drill press**

THE SAME SLIDING, swivel and tilt mechanism used when sawing with the radial arm saw can be used for boring up to one inch holes in wood.

Unlike the conventional drill press, the radial arm machine bores holes horizontally, instead of vertically. There are no restrictions on the length or width of the stock you can bore as there is with a drill press due to its throat size or length of spindle feed. The depth of the hole to be bored on a radial arm machine is limited only by the length of the drill bit.

*Mounting the drill bit.* First remove the saw blade and arbor collars from the motor shaft and screw on the drill bit adapter, tightening it with the wrenches. Then insert a bit of the required size in the adapter hole

and tighten the retaining setscrew. Right- and left-hand thread adapters for use at both ends of the motor shaft are available for most current radial arm saws, so that either right- or left-hand feed drill and router bits may be used. On older models of radial saws only the left-hand adapter and left-hand feed drill and router bits can be used.

*Wood-boring operations and setups.* To support the work at right angles to the saw table when face-boring, make up the face-boring jig and clamp it to the saw table after removing the original guide fence strip on the table. Measure and mark the locations of holes to be drilled in the work with a sharp, hard pencil and "center-punch" with an awl. The punch mark will help lead the drill into the work accurately, especially when working with fir which has alternating hard and soft grain.

Align the drill bit with the marked locations of the holes on the work by sliding it from one side to the other on the boring jig and raising or lowering the saw arm with the elevating screw. Then feed the drill into the work by pushing the motor carriage. When drilling a deep hole, retract the drill once or twice to clear the chips and avoid burning the bit. To prevent the drill from going through the jig and striking the saw column, clamp a stop block on the saw arm.

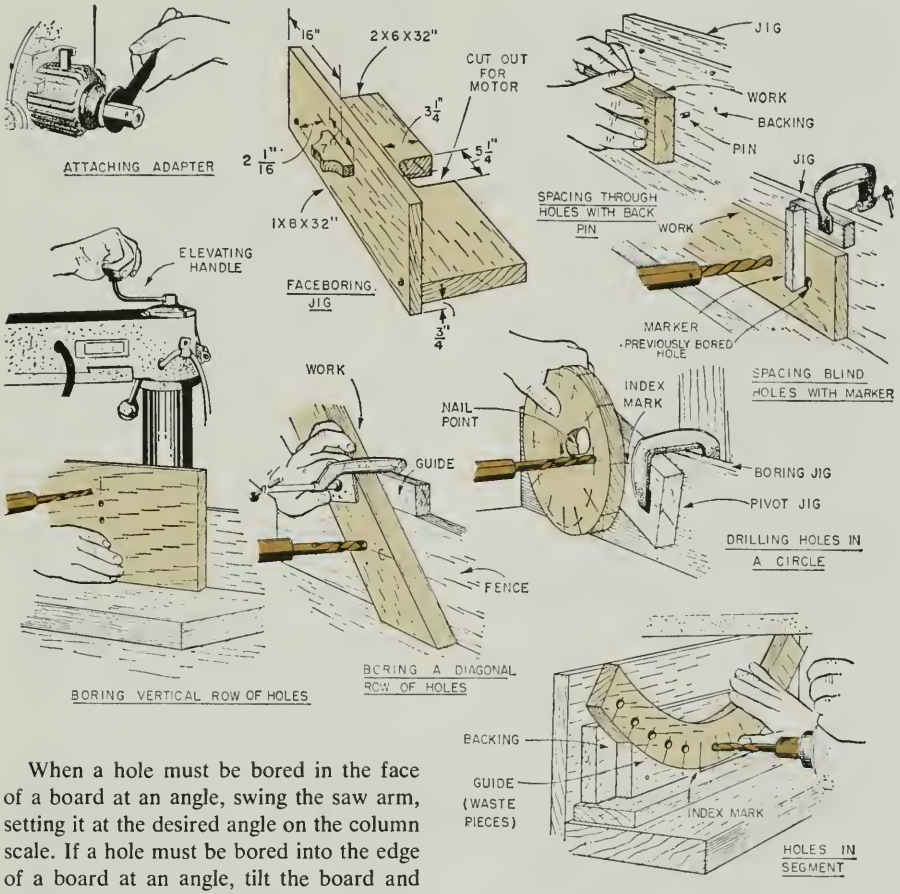
When a series of equally-spaced holes is to be bored, set a short dowel into a backing board and temporarily tack the board to the boring jig so that the pin will engage a hole already bored. Locate the pin so that the next hole bored will be correctly spaced. By entering the pin in successive holes they will be spaced as desired. If the holes are not to go through the work, make an ell-shaped marker from two blocks of wood and clamp it to the boring jig where the marker will align with the edge of a previously bored hole, thus locating the next hole.

To space holes in a vertical row, raise or lower the saw arm. A diagonal row of holes can be aligned by clamping a guide bar to the back of the work parallel to the row of holes. Sliding the guide on top of the fence keeps work at desired angle. If the work is too large for this setup, handle it as in ordinary face-boring, aligning the bit by sliding the work on the jig and raising or lowering the saw arm.

Holes arranged in a circle are easily located radially by use of a pivot jig consisting of a board with a nail point projecting which is driven into the back of the work centering on the hole layout circle. Clamp the pivot jig to the boring jig. The work can be indexed by bringing a center line marked on the edge of the work to an index mark on the jig. Holes in segments are bored by resting the outer edge of the segment in a guide made from the waste pieces sawed from the segment. Again, indexing is by center lines brought to an index mark on the guide.

To bore holes into the edge of a piece of stock, lay the work face down on the boring jig and against the fence and proceed as for face-boring. Mortising is accomplished by first boring holes at the ends of the mortise and then boring a series of holes between. The remaining webs are removed by boring through them and working the piece lengthwise against the rotating bit. For boring edge holes in segments, use a horizontal setup similar to that for face-boring segments.

End-boring is done with the motor in normal sawing position and the piece resting on an end-boring jig. Clamp the jig to the saw table after removing the original guide fence and place the work on the jig. Adjust the saw arm for height, slide the motor along the arm to center the bit on the work, and tighten the carriage clamp screw. When boring, feed the work into the drill bit by sliding it along the jig fence. A stop block can be nailed or clamped to the jig to limit depth of boring.

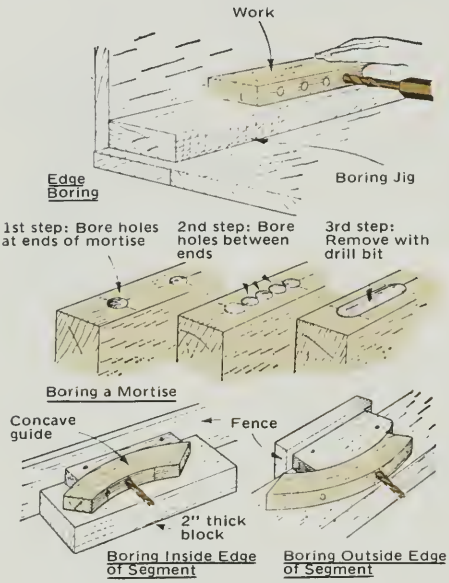



When a hole must be bored in the face of a board at an angle, swing the saw arm, setting it at the desired angle on the column scale. If a hole must be bored into the edge of a board at an angle, tilt the board and rest it on angle blocks. Such a setup is useful when boring dowel holes in the mitered edges of column staves. If a hole must be bored at an angle to both the width and length of a board, tilt the board and swing the saw arm to desired angle.

Frames with mitered corners are often strengthened by inserting dowels. This is a modification of end-boring, but with the piece swung away from the jig fence to bring the mitered edge at right angles with the drill bit. A block, cut to a 45° angle, and placed behind the work and against the jig fence can be used to position and hold the work while boring. More convenient for angle boring is a jig made from two pieces of plywood. A wing nut on a carriage bolt, with the head sunk flush into the underside, locks the swiveling member of the jig at any angle. Face the working edge of the jig with sandpaper to prevent work from slipping, and mark the angles on the base of the jig with a sharp pencil. In use, place the work on edge and space the holes by raising or lowering the saw arm.

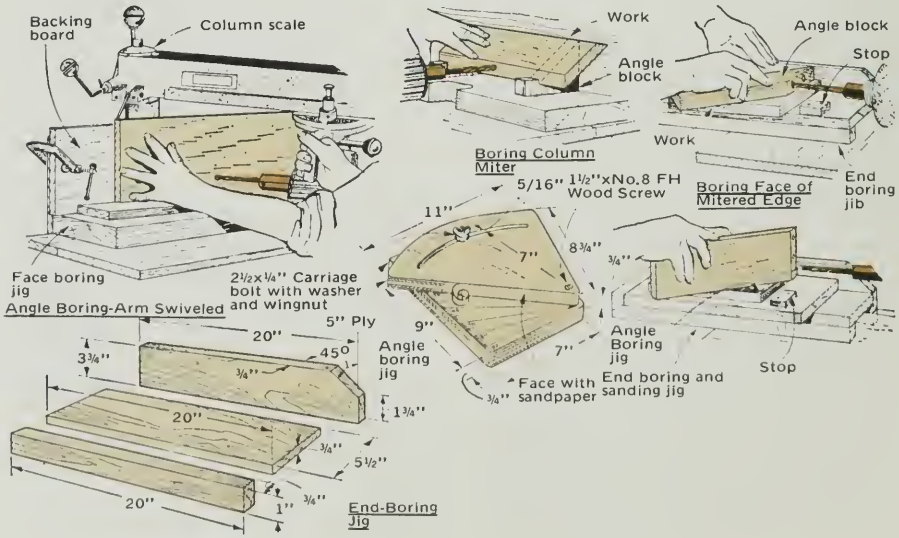
*Routing.* By substituting a router bit for

the drill bit the radial arm saw becomes a routing machine. The router bits, which are available in several sizes, are held in the boring bit adapter. Set the motor in a vertical position and rest the work on the table. If the surface of the table is cut up and rough from use, tack ⅛-inch tempered hardboard over it.




Cutting a rabbet along the edge of a piece of stock is a typical routing job. To do this, set the saw arm at right angles to the fence, push the motor back until enough of the router bit is forward of the table fence to cut the width of the rabbet. Then lower the motor so that the router bit will take a cut ⅛-inch or less in depth. For deeper cuts, make several passes each ⅛-inch deep. Lay the work face down on the table with the edge to be rabbeted against the fence, and feed forward to the left. If the router bit is not large enough to make the rabbet the desired width, move the motor back, lock it, and take another pass. For a stopped rabbet, clamp a block to the table where the end of the board will strike it when the rabbet is long enough, or mount the block on an extension for long work.

Routing is a convenient method of recessing a window-screen frame for the mold-



ing. By tacking a wooden wedge to the table to limit the width of the rabbet, the inner edge of the frame can be slid against the wedge while being held at right angles to it. It works well into the frame corners, leaving little chisel work to square the corners.

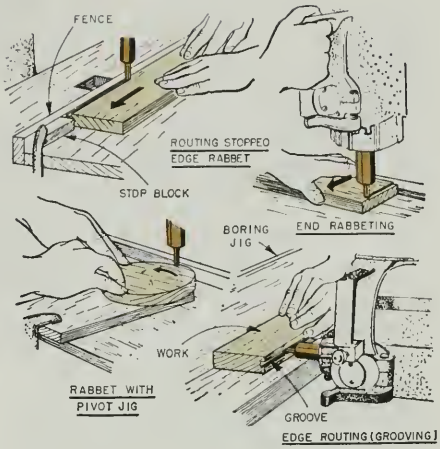
When end rabbeting a piece of stock, hold the work against the fence and pull the motor toward you to make the cut. Extend the piece to the left so that cutting will be against the rotation of the router bit. When rabbeting the edge of disks use a vee or fitted edge guide, or a pivot jig.

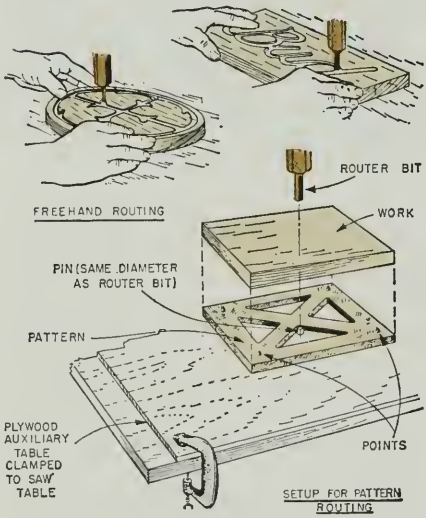
The router bit can also be used for grooving and dadoing by following the same methods as for rabbeting, except that the cut is wholly enclosed. Make the start of a blind groove by lowering the router bit into the wood as you would a drill. Use the boring jig to raise the work high enough for edge grooving.

When dadoing a series of equally spaced cuts place a notched stick into a previously cut dado, clamping the stick to the fence where, when entered in the first cut, it will bring the next cut properly under the router bit. Clamp a stop block to the arm when making blind dadoes.

Freehand routing is useful for planing down the backgrounds of carvings and making sunken or carved lettering in signs. For this work set the motor vertical and locate it near the center of the table where the work piece can be slid around under the bit. Use a bit having a diameter equal to the narrowest portion of the design.

Freehand routing is likely to produce cuts that are somewhat irregular because the bit tends to follow the soft grain of the wood. Accurate outlining of a design, however, is possible with pattern routing, providing the pattern, jigsawed from thin plywood or hardboard, is accurately cut and smoothed. The pattern is tacked to the underside of the work piece. A dowel the size of the router bit is sunk in an auxiliary table, and the router is exactly centered on it. Then the pattern is lowered over the dowel until it rests on the table, the cutter is lowered into the work, and routing proceeds by guiding the pattern against the dowel.




M.E.

*See also:* POWER TOOLS; TOOL TECHNIQUES; WOODWORKING.

# How to Restore a Vintage Radio

**Bring a bit of nostalgia to life by restoring an old 1920's radio and making it work**

WITH NOSTALGIA BEING the in thing for these times, how would you like to rekindle some of the adventure of the 1920's when everyone was a DX hound? Those were the early days of radio when the big thing was to twiddle those many dials (the more the better) and edge a little closer to the horn speaker trying to catch those faint call letters of a distant radio station.

Restore an antique radio and you will have a conversation piece that won't quit. Don't think for a minute that restoration is difficult; vintage radios were the height of simplicity. Take a quick look at the typical circuit diagram and you will agree, for it is an ordinary TRF (tuned radio frequency) with inductively coupled RF amplifiers, a demodulator or detector, followed by transformer coupled audio frequency amplifiers. This type of circuit was called a *neutrodyne* and was representative of most early broadcast band receivers. The superhet had made its appearance in 1923 but it was too expensive, and too difficult to tune (at that time), for the average homeowner so he was content with his neutrodyne.

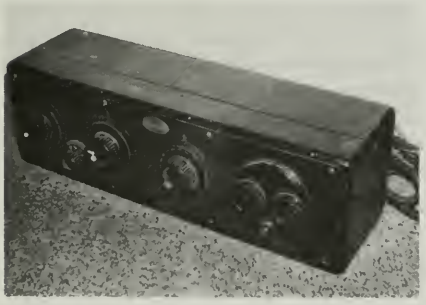
*Start the hunt.* Part of the fun of restoration is the search for the radio set. Do a little nosing around junk shops or flea markets or talk to a radio ham from the older crowd who might have one or two tucked away. Some collectors have found hundreds of sets this way. When you make your find don't expect your set to look too shipshape. Remember it is at least 45 years old and probably has been kicking around in someone's attic for most of that time. Be on the lookout for components obviously missing. If you see a lot of bare wires going nowhere then that's a dead giveaway that someone already rifled some of the parts.

Take a pocket ohmmeter along and check the tubes for filament continuity. You'll find that they are likely to be 201-A's, and the two fat prongs are the filament.

**radio-alarm-intercom systems:** see intercoms
**radio, boat:** see electronics
**radio, cb:** see citizen's band radio
**radio servicing:** see high fidelity systems

If you read about 2 to 10 ohms, you're in business. Usually, with a good filament, you'll find that the 201-A's will work okay. Strangely enough the big tube companies still list 201-A's, and they may be purchased from some of the smaller mail order firms. Send a few postcards to them requesting tube lists.

*Technique is important.* Restoring an antique radio involves the same treatment as for an antique car. Both should look as if they just came out of the factory. This is all done very simply by refurbishing all the component parts. The one described here is an Atwater Kent Model 20, but the techniques described can apply to any of this vintage. This model adorned many living rooms in the mid-1920's and sported the three large tuning dials which was typical of the front panel appearance of most sets in this period. (The techniques which allowed the use of a ganged tuning capacitor was yet unknown.)



*What good is good luck in finding an old, worn-out Atwater Kent receiver (above) if you don't know what to do with it. First, inspect it carefully outside and inside (below) before you buy it. Make sure all the parts are there!*

*Restoration is easy and a simple process that any amateur can tackle. Begin by removing chassis from cabinet. Next, remove knobs and front panel plates.*

*Then, tear down rear assemblies. Be sure to save the screws, as you will need them later when you are ready to reassemble the radio.*

You are more likely to find one of the Atwater Kent models because thousands were built during that era. How much should you pay? That is almost impossible to answer. As a guide, the Model 20 should go for $10 to $50, depending on condition. In getting started, make a hand sketch of the parts arrangement and where all the wires go.

If you are lucky you might acquire a set with shiny square bus bar wire all neatly bent and shaped to make everything look parallel. Even in the most elaborate sets there are not many wires and you will find

(VIEWED FROM BOTTOM)

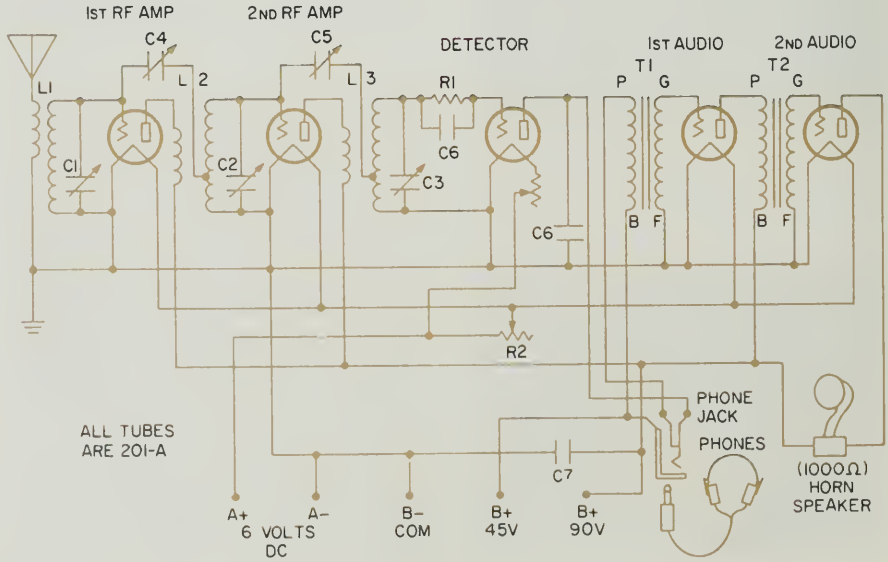
| | |
|---|---|
| FILAMENT VOLTS | 5.0 VOLTS DC |
| FILAMENT CURRENT | 0.25A |
| MAX PLATE VOLTS | 135 VOLTS DC |
| PLATE CURRENT | 3.0mA |
| AMPLIFICATION FACTOR | 8.0 |
| PLATE RESISTANCE | 10000Ω |
| POWER OUTPUT | 250mW |

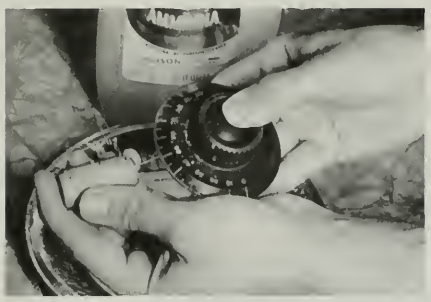
*The 201-A vacuum tube did multiple duty in the Atwater Kent receivers. Replacements may be hard to find so handle yours with care.*

*The Atwater Kent Model 20 broadcast band receiver uses five vacuum tubes powered by dry and wet cell batteries. Capacitors C1, C2, and C3 tune the Iront end much in the manner of later day TRF's except that each capacitor was tuned independently.*

the sketching easy to do. Most models were hand-crafted and parts were held in place using 6-32 machine screws. This makes it easy to accomplish the next step which is to take the whole set apart. Mix up a batch of 1 part sudsy ammonia and 4 parts water and give all the parts a bath except the dials. Don't let the coils stay in too long for it will dissolve the shellac and you will then have a room full of wire. Rinse in clear water and dry by playing a heat lamp over them. Be careful—do not overheat. The tube sockets can be disassembled and the brass shell and prongs polished with ordinary brass polish.

*Maintenance.* After the parts have been cleaned up, how do you check them? The whole set is predominately RF coils and audio transformers, so a simple resistance check of windings will usually show if anything needs attention. The circuit diagram here shows the approximate value in DC ohms. If you find an open RF coil, it is usually the wire terminations on the soldering lugs which can be easily repaired. If you





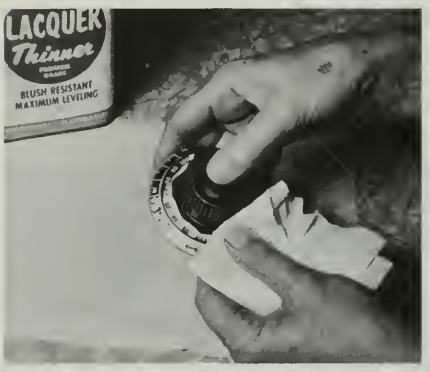
*Restore dials by first cleaning them. Sewing needle stuck in a wine-cork handle scrapes old lacquer and dirt from dial scale.*

*After cleaning, cover indentations with white lacquer, then wipe off excess, leaving lacquer only in the depressions.*

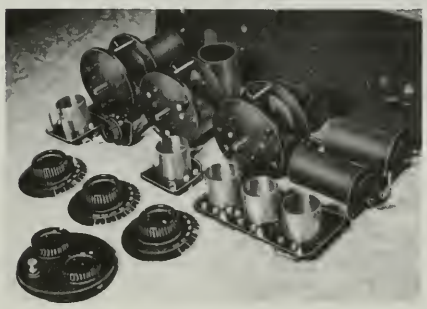
find an open interstage audio transformer it takes a little more work unless it has an obvious broken lead. Allied Electronics has a modern replacement No. 705-0805 that works very nicely.

Of course you can't plop a modern looking transformer among all the antique parts. Fortunately most all early audio transformers were enclosed in a metal can or case and are a thing of beauty with a fancy nameplate, binding posts, etc. Remove the lamination assembly from the case. If you have an Atwater Kent this might mean that the laminations are potted so this requires gentle heating of the can while tugging on the wires. Soon the whole works will pull out encased in a black compound. Drop the new one in and seal it off with paraffin. Even the most practiced eye will not be able to tell it from the original.

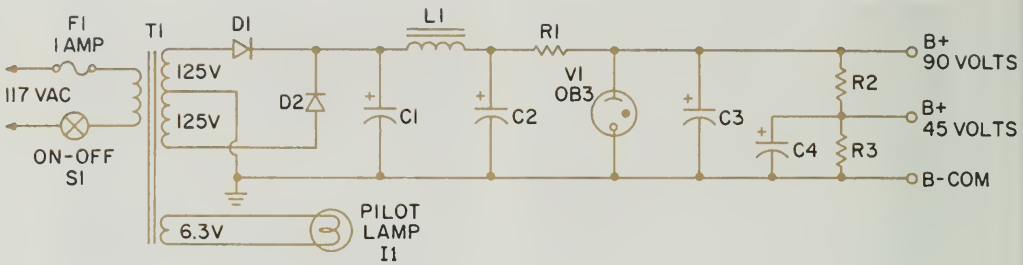
*Dials.* The biggest impression one gets from restored antique radios is big brightly shiny new looking dials. And it is not hard to get them looking that way. However, test the dials to see if they are made of restorable bakelite. This is done by rubbing a paper towel moistened with lacquer thinner on the back of the dials. If you get a very black deposit on the towel this means it is a so-called composition type and is not restorable by ordinary means. However, this is rare. Most sets have bakelite dials




*Moisten a paper towel in lacquer thinner—not too wet—and gently rub across dial to remove excess white lacquer.*



*After all parts are cleaned as described in the text, your receiver should stack up like this. Test the parts and you are ready to reassemble.*




*Feel free to use overrated transformer and electrolytic capacitors.*

| PARTS LIST | |
|---|---|
| C1, C2, C3 | 30 μF electrolytic capacitor, 250 VDC |
| C4 | 1.0 μF electrolytic capacitor, 150 VDC |
| D1, D2 | Silicon rectifier, 100 mA, 500 PIV or better |
| I1 | Pilot lamp. 6.3 V unit (G.E. #47, etc.) |
| L1 | Filter choke, 1 Henry, 30 mA, 100-ohms DC approximately (use secondary filament winding of inexpensive 117/6.3 V transformer) |
| R1 | 2,700-ohm, 7 W wire-wound resistor |
| R2, R3 | 10,000-ohm, 7W wire-wound resistor |
| T1 | Power transformer: 117 V pri.; 250 V CT at 25 mA, 6.3 V at 1.0 A sec. (Stancor PS8416 or equivalent) |
| V1 | OB3 voltage regulator tube |

*Reassemble the radio carefully. Don't worry about lost screws—only 6-32 brass jobs were used in those days.*

*Refinish the cabinet following advice of your paint dealer. Sand first for smooth finish.*

and yours will probably come with this type.

Next, pick up a small can of white lacquer from the paint store. Be sure it is snow-white by first painting some on a board. Now soak the dials in the sudsy ammonia for a few minutes to help loosen the old white lacquer imbedded in the dials' numbers and graduations, all of which has to be removed. With a cotton swab, paint over the dial's indentations as shown in the photo. After the drying period, the next trick is to remove all the excess white lacquer and leave just that in the numbers and graduations. The photo shows you how and while removing the lacquer you might notice that ordinary paper towels are sufficently abrasive to polish the bakelite. Actually, stiff felt blocks were used, soaked with lacquer thinner, in the old days.

Some experimenters are so tickled with

the results of the dial's restoration, that they are content to stop here! But, you can spray a lasting finish by using high gloss clear polyurethane varnish available in spray cans everywhere. Actually this spray finish will also immensely improve the appearance of all bakelite parts like the tube socket bases, etc. When you have them disassembled try hitting one with the spray and you'll be convinced. Remember, we are trying to make everything sparkle.

*Front.* The front panel needs attention next. If it is metal, it can be repainted with the many antique type finishes available. If it is bakelite, clean it first using a gentle spray of ammoniated window cleaner. Then rub it down with a paper towel moistened in lacquer thinner. If it is engraved, restore the markings the same way as for the dials, except don't spray with the varnish.

*Power.* If your radio was built before 1928, it doesn't have a built-in power supply. It is now necessary to sift through the junk box and dig up enough parts for a replacement for the big B batteries that used to provide the plate voltage. The circuit is shown.

We did not provide a diagram for a filament supply which was a 6-volt car battery back in the old days. A normal complement of five 201-A tubes would draw 1.25 amps which takes a pretty healthy (and expensive) transistor regulator. Most of the listening to your radio will be to demonstrate to friends and a 6-volt lantern battery suffices very well.

Your radio is now ready to go. Main tuning is accomplished by tracking C1, C2, and C3. Capacitors C4 and C5 (condensers to the antique radio buff) are for neutralizing out the squeals and squacks prevalent in the RF amplifiers. Your Atwater Kent might not have these. They are adjusted by tuning in a strong station, then killing the filament voltage to the preceding tube and adjusting for minimum signal.

So have fun with your restored antique radio. You'll need some kind of an antenna (preferably a long wire) and a ground connection. If you did a good job on the restoration you can re-create some of the high adventure enjoyed by granddad and tune in stations from coast to coast. H.S.

*See also:* ELECTRONICS.

*Carefully install the receiver chassis and front panel into the cabinet.*

*The completed Atwater Kent in restored condition and ready to play. Note B+ power supply and filament battery behind unit.*

# Restoring a Clock Radio

**Here's how to replace a broken radio element in a clock with one that works**

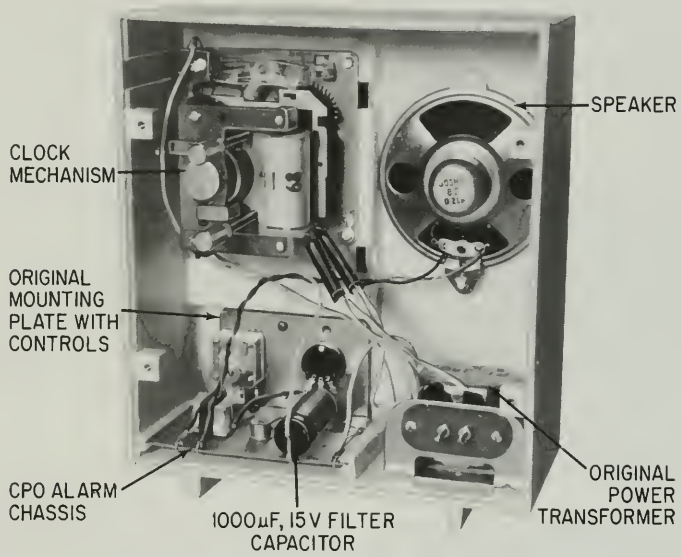
WHEN THE CLOCK RADIO fails, it is hardly worth while trying to find out why the radio chassis quit. Unless the trouble is something obvious like a bad electrolytic capacitor or output transistor, why not replace the AM radio chassis with a new one? If you have a portable transistor radio with a broken case or a bad speaker, you can use it as a replacement chassis by making a simple change in the clock radio power supply. If you have no spare transistor radio, you could install a code practice oscillator in place of the radio. It will not awaken you to music, but it will wake you up with the tone of your choice.

*Radio replacement.* If you decide to replace the AM radio chassis with a working unit, it is a good idea to retain the tuning capacitor and audio gain control of the original clock radio. The original knobs may then be used without the bother of having to mate them to replacement control shafts. The only catch is that the tuning capacitor of both receivers should be electrically identical for proper tuning.

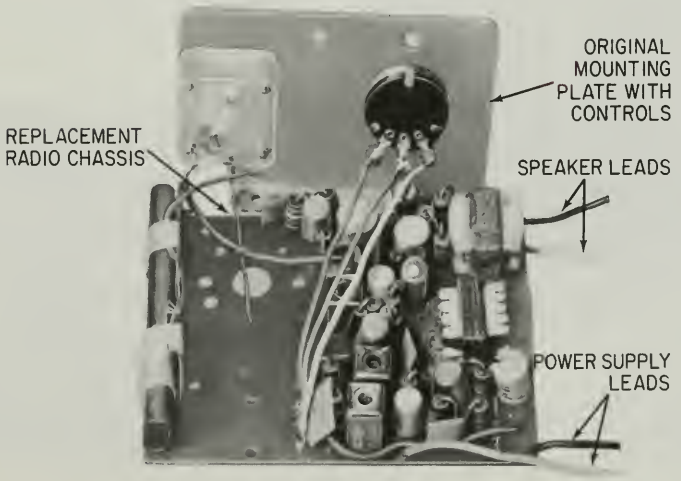
Simply remove the mounting plate with the controls on it from the defunct chassis and wire the assembly to the replacement chassis after removing the old tuning capacitor and gain control. The additional lead lengths make no difference in the performance of the replacement set. Also, the modification will not affect tuning dial settings noticeably, since these receivers have only an approximate tuning scale. However, to be safe, keep the leads reasonably short. This completes the mechanical job of adapting the replacement AM chassis to the cabinet.

Many clock radio chassis run on a 15-VDC supply instead of the usual 9-VDC for portables. If your replacement chassis is designed for 9-VDC, you may still use the original power transformer in the clock radio, but it will be necessary to add a dropping resistor in the DC filter circuit of the power supply. See the Power Supply sche-

matic diagram. Experiment with the value of the series dropping resistor, R1, until the voltage to the chassis is about 9-VDC. Start with, say, 1000 ohms and gradually decrease the resistance value until the proper voltage is obtained with the AM radio




*Here's a great way to salvage a good clock that caught radio failure. The solution includes either a new transistor radio chassis or your own home-built one-transistor tone generator.*



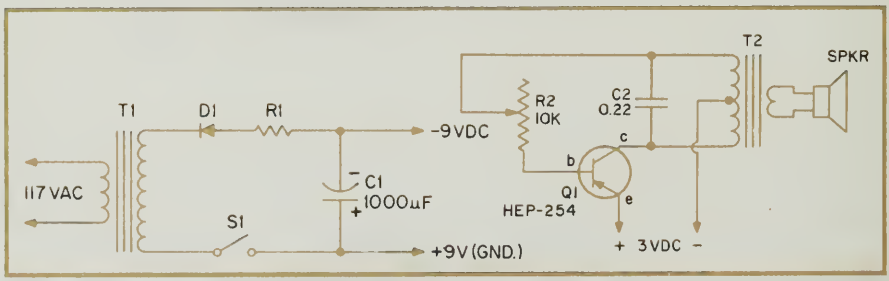
volume set at minimum. A convenient way to do this is to use a potentiometer. There is no danger of damaging the potentiometer since the power dissipated is only a fraction of a watt. Remove the potentiometer from the circuit and replace it with a one-watt fixed resistor that closely approximates the potentiometer setting. Insert the fixed resistor into the circuit and recheck the voltage.

Now check the performance of the receiver at normal volume. The power supply voltage will drop on volume peaks, but not enough to cause serious distortion.

*Code practice oscillator.* If you have no suitable AM chassis available as a replacement, why not install a code practice oscillator instead? Its dulcet tone will awaken you just as readily as any local radio station would. A suggested circuit for the CPO, using a minimum of parts, is shown in the CPO schematic diagram. The oscillator requires 3 volts, or so, for proper operation and a series dropping resistor, R1, in the filter circuit should be selected as described previously to give this output voltage.

The 5000-ohm potentiometer, R2, should be adjusted for a pleasing tone and, if you prefer, replaced with a fixed, ½-watt resistor of the nearest standard value. In some cases, it may be necessary to add a capacitor, C2, across the primary of T2 to get the tone you want, since the frequency of oscillation of the oscillator depends to a degree upon the characteristics of the transformer used. Do not use a capacitor larger than .25 μF. It may result in unstable oscillation and low output. After the capacitor is permanently installed readjust R2 for a pleasing tone and check the oscillator for prompt starting. F.J.B.

*See also:* ELECTRONICS.




**PARTS LIST—Power Supply**

| | |
|---|---|
| C1 | 1000-μF 15-VDC electrolytic capacitor. (Use capacitor in clock radio or replace with Radio Shack 272-1008, or equivalent) |
| D1 | Diode rectifier, 200 PIV, 1A. (Use unit in clock radio or replace with Radio Shack 276-1102, or equivalent) |
| R1 | ½-watt resistor. (See text for selecting value) |
| S1 | SPST switch. (Alarm switch in clock movement) |
| T1 | Power transformer. (Use unit in clock radio or replace with 115-VAC primary; 12-VAC, 1.2-A secondary; or Radio Shack 273-1505) |

**PARTS LIST—CPO**

| | |
|---|---|
| C2 | 0.22-μF, 100-VDC disc or tubular capacitor. (Radio Shack 272-1070, or equivalent) |
| Q1 | Audio transistor, PNP, 2N427, 2N396, SK3004, HEP-2, HEP-254, etc. (Radio Shack 272-2005, or equivalent) |
| R2 | 5000 or 10,000-ohm potentiometer, taper not critical. (Radio Shack 271-218 or equivalent) |
| SPKR | Use original unit in clock radio or replace with speaker of same physical dimensions. |
| T2 | Audio output transformer. (Salvage from old transistor radio or Radio Shack 273-1381, or equivalent) |

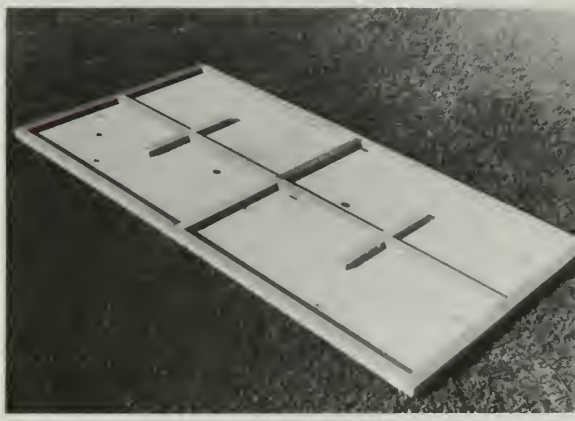
# Build a Raft for Youngsters

**Paddling around on this easily built float will give children hours of pleasure**

THIS SMALL, EASY-TO-MAKE raft will delight children for hours at a stretch.

The main structure is a wooden framework and Styrofoam sheeting sandwiched between two 4 x 8-foot sheets of ¼-inch marine grade plywood. Two automobile tire inner tubes are lashed beneath the structure to increase flotation.

Make the frame first, cutting and notch-

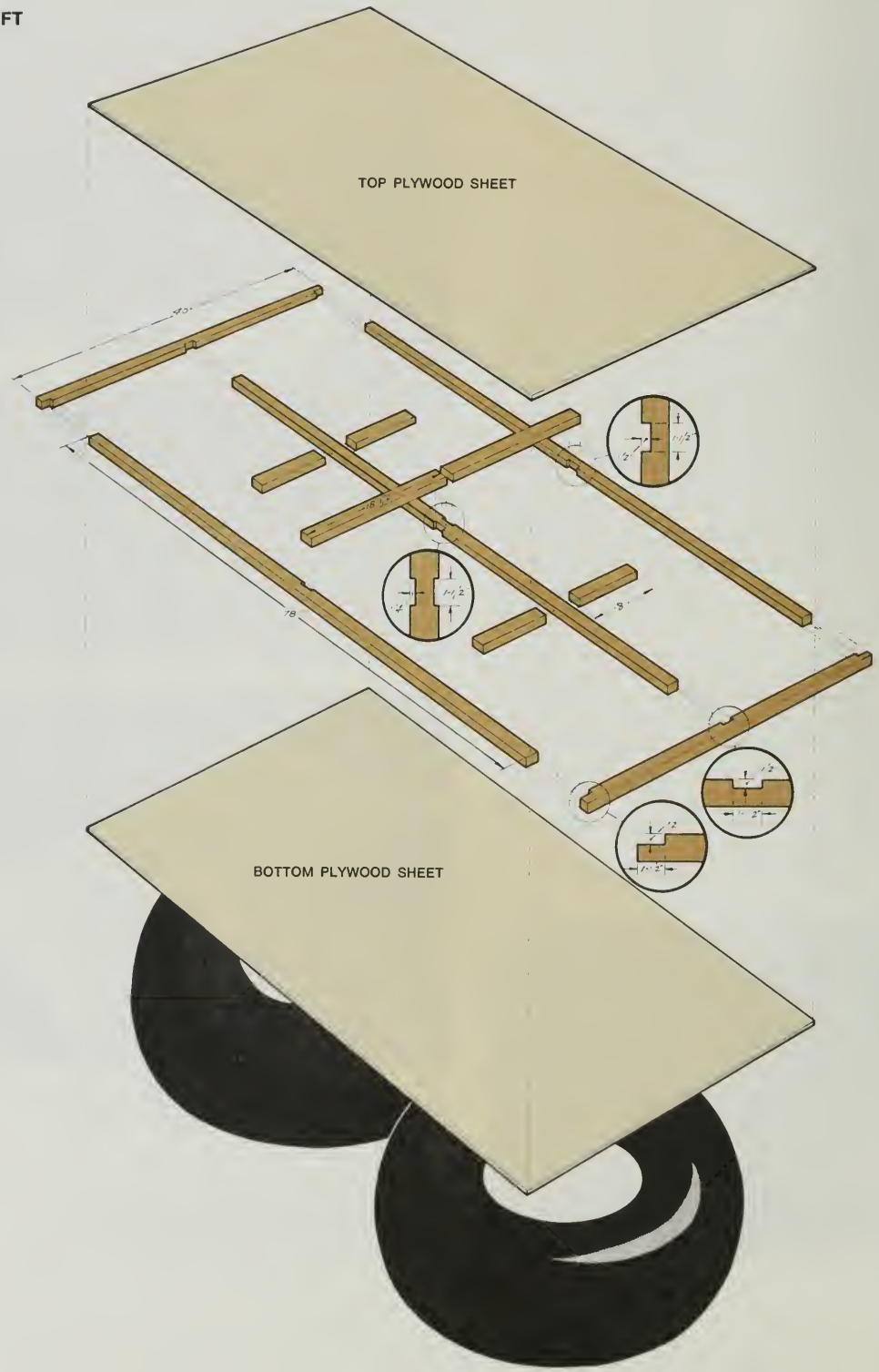


*Use glue and 1-inch galvanized or aluminum common nails to attach the plywood sheet to the frame. Coat all inside surfaces with wood preservative.*

*Assemble the frame for the raft with plastic resin glue and 2½-inch galvanized or aluminum common nails. Pre-drill the nail holes.*

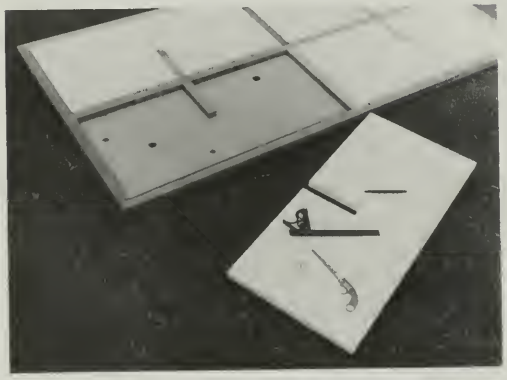
**rafters:** see home improvement

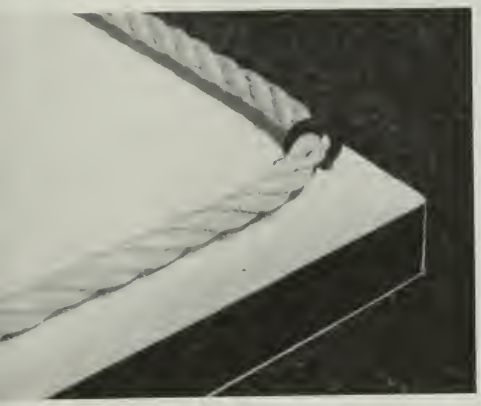
**RAFT**



*When attaching plywood to frame, space the nails no more than 3 inches apart.*

*Trim the 1-inch Styrofoam sheeting to fit between the frame members.*





*The safety line is threaded through the eyebolts, as shown in the photograph.*

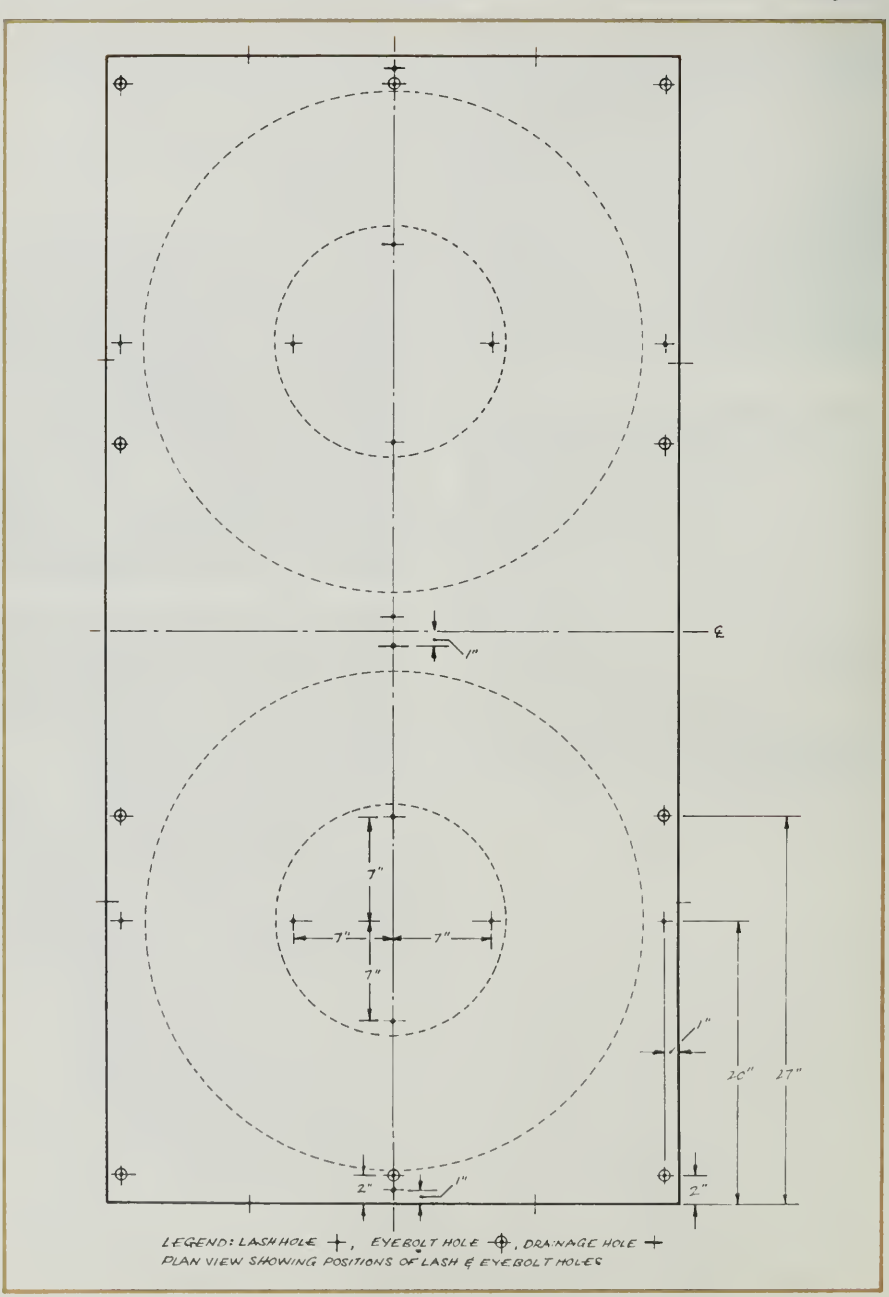
*Use ¼-inch nylon line to lash the inner tubes to the underside of the raft.*

ing the 1 x 1½-inch fir, pine or cedar stock according to the dimensions in the accompanying drawings. Assemble it with plastic resin glue and 2½-inch common nails, either galvanized or aluminum. Pre-drill the nail holes to prevent the stock from splitting.

When the glue is set, nail and glue the first 4 x 8-foot sheet of plywood to the frame. Don't skimp on the nails. The 1-inch aluminum or galvanized nails should be no more than 3 inches apart.

Next, coat the inside of the partially completed structure with wood preservative and let it dry. At the same time, coat the inside surface of the second sheet of plywood.

Trim the Styrofoam sheets to fit within the framework and complete the sandwich by nailing and gluing the second sheet of plywood over the open face.




LEGEND: LASH HOLE ⊕, EYEBOLT HOLE ⊕, DRAINAGE HOLE ⊕
PLAN VIEW SHOWING POSITIONS OF LASH & EYEBOLT HOLES

Drill ¼-inch holes for the eyebolts and ⅜-inch holes for the lashing and for drainage holes. Locate them precisely according to the drawing.

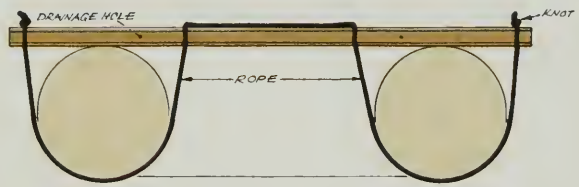
Sand the structure completely and install the eyebolts, using two fender washers per bolt. Make sure the eyebolts, nuts and washers are all cadmium finished. Paint and decorate the raft using marine undercoat and enamel.

When the paint is dry, install a ½-inch nylon safety line around the edge of the raft through the eyebolts and lash the inner tubes to the under side of the raft with ¼-inch nylon line.

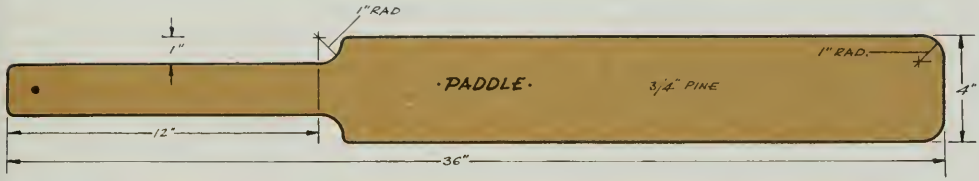
Cut the paddles according to the drawing out of ¾-inch pine stock and paint them, again using a marine finish.

*Original design by Steve Ellingson.*

*See also:* BOAT BUILDING; BOAT BUILDING PROJECTS; PADDLE WHEELER; RACING BOAT; RUNABOUTS; SURFBOARD.




CROSS SECTION SHOWING TYPICAL LASHING OF INNER TUBE TO UNDERSIDE OF RAFT




**MATERIALS LIST**

| Quantity | Size and Description | | Purpose |
|---|---|---|---|
| 2 | 1/4" | 4'x8' exterior or marine grade plywood | top and bottom |
| 4 | 1" | 1½"x80" pine, fir or cedar | frame |
| 1 | 1" | 1½"x70" pine, fir or cedar | frame |
| 1 | ¾" | 9"x36" pine | paddles |
| 4 | 1" | 18"x38" Styrofoam | |
| as needed | 2½" | aluminum or galvanized common nails | frame |
| as needed | 1" | aluminum or galvanized common nails | plywood sheets |
| as needed | 1/4"x3" cadmium finish eyebolts and nuts | | |
| as needed | 9/32"I.D.x1⅛"O.D. cadmium finish fender washers | | |
| | 1/4"x40' nylon rope | | lashing |
| | 1/2"x25' nylon rope | | safety line |

**NOTE:** Also need inner tubes, wood preservative, plastic resin glue, wood filler, exterior or marine enamel and undercoat.

# Improve Your Home with Wrought Iron Railings

**This addition to the safety and appearance of your property will also increase its value**

WROUGHT IRON RAILINGS are not difficult to install, and they can add to the appearance as well as the safety of your house.

Aside from ordinary hand tools, you will also need an electric drill to do the job and, if you intend to mount the railing on concrete or brick, a masonry bit. You will also need the railings, posts, columns if you plan to use them, and lag screws, masonry anchors or quick-setting cement to anchor the fixtures.

Start by drawing a chalk line 3½ inches in from all outer edges of the platform and stairs where the railing is to be installed. Measure the entire installation and prepare a scale drawing. This step is easier if you use graph paper for the drawing.

When measuring stairs, measure the diagonal distance from the edge of the platform down to the edge of the first step. This method will give you the actual length of the railing required.

Use the scale drawing to work out the number of posts, pillars and railing sections you require. First, mark the location of any end or corner post or columns you require. Then, measure the total length of railing to determine the number of four- or six-foot sections that will be needed. Generally, one-inch wide railing comes in four-foot sections and 1¼-inch wide railing comes in six-foot sections.

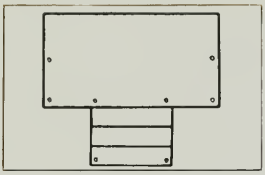
If a railing on a platform such as a porch or breezeway spans a distance greater than the length of a railing section, figure on using additional support posts. For example, an 18-foot length of railing would require three six-foot sections and two intermediate posts. On stairs, posts should never be more than four feet apart.

When you are figuring the dimensions, take into account the widths of support posts and columns. Support posts are usually either 1¾ or 1½ inches square and columns are either 9 or 10½ inches wide, depending on style. Make these choices before you lay out your railing.

For best appearance, the supports for any straight run of railing—along the side of a porch or up a stairway, for example—should be evenly spaced. Each railing section should be the same length.

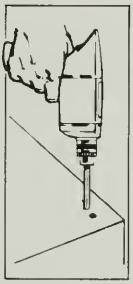
Count the number of railing sections, support posts and columns required and figure on four connectors for each section of railing. Also, if the support posts are to be surface-mounted rather than imbedded,

**range, electric:** see electric range
**rasps:** see hand tools
**reciprocal sander:** see abrasives
**recreational vehicle:** see campers
**refinishing supplies:** see finishing, wood

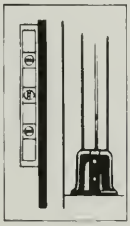


*Lay out your railing plan on site with chalk and check it out before ordering the parts. Mistakes can be costly.*

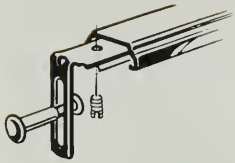
*When several posts are required, the railing will have a better appearance if the sections between the post (usually four or six feet) are all of equal length.*

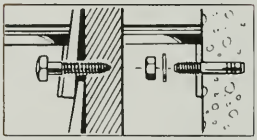


*Use a masonry bit to drill concrete or brick. To make a square hole for embedding a post, drill the four corners to depth and chisel out the remaining concrete.*

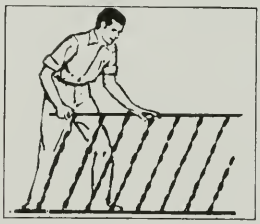


*Use a spirit level to make certain the posts are vertical.*





*To attach post to rail, insert clip into rail and tighten screw. Then bolt vertical member to the post. To attach railing to house wall, use lag screw or masonry bolt to hold vertical member.*



*To slant railing for use on stair or ramp, just place it on the ground, hold the top firmly and push.*

*To attach stair or ramp railing to platform railing, simply bend the clip as shown to conform to the angle of the railing.*

figure on one support flange for each post, as well as lag bolts for mounting them to wood or masonry anchors for use with concrete or brick. Add any decorative accessories to your list and it is ready to take to your supplier. It also is a good idea to take your scale drawing, in case you have any questions.

When you are ready to install your wrought iron railings, first mark the position of each corner and end post or column with chalk on the porch or stair.

If you are using mounting flanges and masonry anchors, place the flange in position on the surface and mark the position of the mounting holes. If the flanges have only two holes each, line the holes up perpendicular to the railing. Remove the flange and drill holes of proper size with a masonry bit. Then use masonry anchors to fasten the flange in place.

If you are embedding the posts, mark a two-inch square on the masonry surface for each post or column leg. Drill a ½-inch hole 3 inches deep at each corner of a square and chisel out the material between the holes.

Erect the posts and columns temporarily, using a level to make sure they are plumb, and position the railings in place between them, marking them to correct length. If cutting is necessary, remove an equal amount from each end of a section to maintain balanced spacing of rail spindles.

Shorten platform posts to be installed with flanges to 33½ inches if you wish to install the railing flush with the tops of the posts. Cut the bottom and intermediate stair posts to 34½ inches.

If you wish the railing to be one-inch below the tops of the posts, shorten posts to 34 inches, but leave the bottom and intermediate stair posts 35 inches long.

For posts imbedded in masonry, use a distance of 34 inches and set them 3 inches into the masonry. Leave stair posts 35 inches.

Before you actually cut the posts, hold the railing sections in position to determine the railing height you prefer. It may be somewhat different from what the cutting instructions will provide. Also, actually checking position will enable you to adapt the railings to porches or stairs that may be irregular or out of plumb.

Once you are confident that everything fits, you can install the supports permanently. If you are imbedding them in masonry, use quick setting cement, and use a level to keep them plumb. Remember that columns must be attached at top and bottom. They come with attachment fittings for each end.

To attach the railing sections to the posts, first insert the connectors in the railings and fix them in place by tightening the setscrews.

Then attach the connectors to the posts and columns with the bolts provided. The posts are predrilled, but you will have to drill your own holes in the columns. Use lag screws to attach the connectors to the house where necessary.

To slant a railing section for use on a stairway, simply place it on a flat surface, and push downward and toward one end until the spindles form the correct angle with the railings. This angle is such that when the railing is in place on the the stair, the spindles will be vertical. Check it by holding the section in place and using your eye.

When the angle is correct, cut the railing to fit, if necessary, and trim the ends of the rails at an angle parallel to the spindles so the railing ends will make neat flush joints with the post. Where railing forms an angle up or down, the connector can be bent with pliers or a hammer.

When all the railing sections are in place, paint the whole installation, and the job is done. F.C.

*See also:* BRICKWORK; FENCES; HOME IMPROVEMENT; MASONRY; PANELS; PATIOS.

# Maintaining and Repairing Your Refrigerator

**By operating and maintaining your refrigerator carefully, you significantly postpone the day when it just stops running. And, when the breakdown does occur, you can make the repair yourself 98 percent of the time**

UNDERSTANDING HOW your refrigerator works will help you prolong its useful life and keep it running trouble-free.

Basically, the refrigerator is an insulated cabinet with a refrigeration unit that absorbs heat inside the box and releases it outside.

The word "heat" in discussions about refrigeration is used in a slightly different way than in ordinary conversation. For example, if you picked up an ice cube in your freezer compartment, you wouldn't call it "hot." But it has heat, even though its temperature is fairly close to 0 degrees. It has a lot less heat than a freshly poured cup of tea, but it also has much more heat than an ice cube frozen down to −100 degrees. Think of it as a difference in temperature. If two similar objects have different temperatures, one has less heat than the other and one has more, even if both feel cold to the touch.

Three systems comprise the refrigeration unit—a compressor, a condenser and an evaporater. It works this way. The compresser compresses a refrigerant gas. As the gas is compressed its temperature rises to about 120 degrees and it passes into the condenser. The condenser is a heat exchanger, like the radiator in an automobile. The gas loses heat through the walls of the condenser to the outside atmosphere. The compression and loss of heat change the gas into a liquid.

The liquid refrigerant passes from the condenser through a filter-dryer that removes impurities and then through a capillary tube (about 0.036 inches inside diameter) that meters the flow of liquid into the evaporator inside the cabinet.

The evaporator is also a heat exchanger. Heat in the refrigerator cabinet (even though the inside of the refrigerator feels cold, it has heat that it will transmit to something of lower temperature) is passed through the walls of the evaporator to the liquid refrigerant. The heat changes the liquid to gas. The gas is drawn to the suction side of the pump and begins the cycle again.

In addition to the refrigeration system, the refrigerator has other equipment that

**regulator:** see electrical, auto
**relays:** see remote control switches

makes the system more effective or more convenient to use—a thermostat to control the temperature, for example, or an overload switch to protect the motor, or the circuit that turns on the light when the door is open.

The refrigerants in common use are Freon gases especially compounded for refrigeration. One of these, R-12, has a boiling point of −21.6 degrees F at normal atmospheric pressure. At 120 degrees F its pressure is 157 pounds per square inch. This refrigerant is contained within the completely sealed refrigeration system.

There is nothing that you can do to service a sealed system without an expensive set of tools and test equipment designed for refrigeration service work. Our advice on sealed system service, if needed, is to turn it over to a professional.

Since less than two per cent of the service calls on refrigerators involve a sealed system failure, there is much you can do to keep your unit running at its normal efficiency.

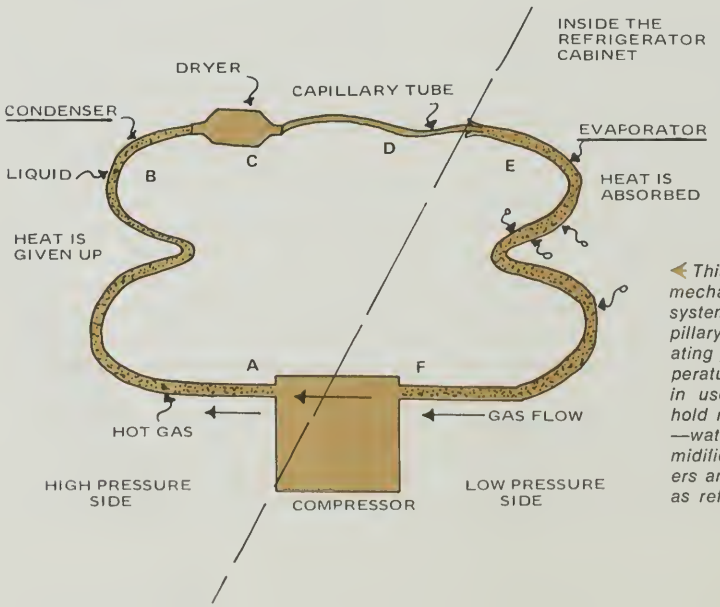
*Refrigerator use.* The use and care a refrigerator gets will affect its life and efficiency of operation. Some detrimental factors are:

1. An abnormal ice cube demand.
2. Excessive door opening and closing.
3. Leaving the door open for long periods of time.
4. Not completely closing the door.
5. Overcrowding that hampers normal air circulation.
6. Careless loading that damages shelves, chips the porcelain liner, cracks breaker strips, etc.

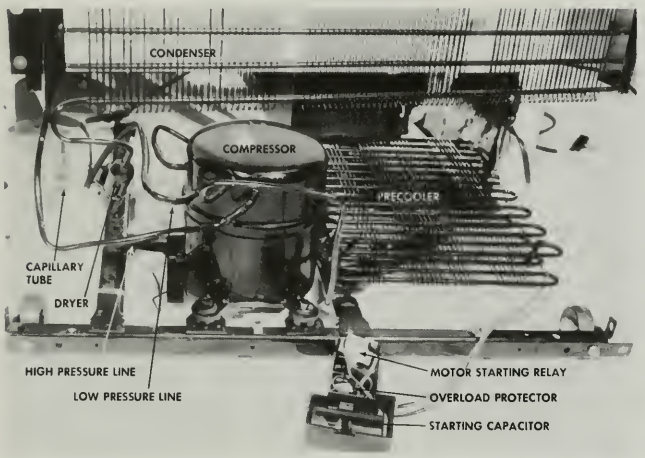
All of these conditions will cause a unit to run more than it normally would. It could be running continuously and yet not remain cold enough to preserve the foods.

*Location.* The refrigerator should be located on a secure, level floor. There should be enough clearance to allow adequate air circulation to carry off the condenser heat. There should be at least a three-inch clearance around the sides and top of a machine without a forced-air condenser.

A machine with a forced air condenser




*This is the basic mechanical refrigeration system. Except for capillary tube size, operating pressures and temperatures, this system is in use in every household refrigeration device —water coolers, dehumidifiers, air conditioners and freezers, as well as refrigerators.*




*These components are those that are normally outside the refrigerator cabinet. They are all high-pressure parts of the system, except for the low-pressure line.*

should have enough space for installation and moving. Make certain the front of the machine, under the door, is clear to allow air flow. The door should swing freely without bumping into furniture or other cabinets.

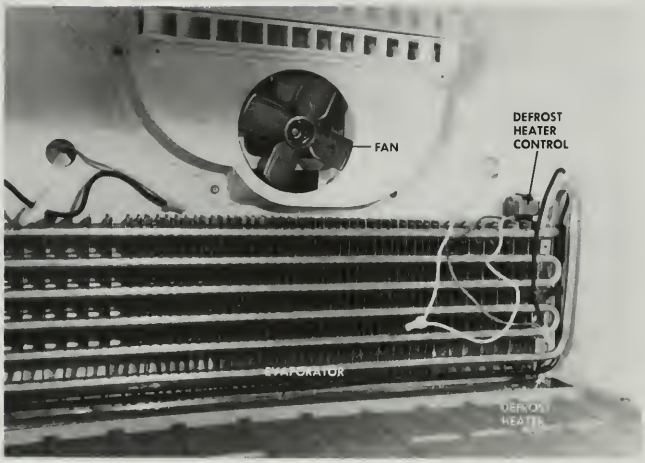
Your refrigerator should also be out of direct sunlight and away from the stove, radiator or other heat sources. It should be dry because a damp location can cause abnormal cabinet rusting and corrosion of the electrical controls. The electrical supply should be within 10 per cent of the nameplate rating, while the unit is running.

*Cabinet care.* Dust, animal hair, newspapers, etc. that collect on the condenser should be removed at least twice a year. This will maintain maximum heat transfer from condenser to air. A vacuum cleaner does this job well.

Scratches on the cabinet and rust spots anywhere should be sanded and touched up as they appear. Door hinges that get stiff or squeaky should be lubricated with a little light oil. Door latches on older refrigerators should operate freely and hold the door securely closed. If they do not, the door gasket or seal will not seat properly around the door. This allows cool air to escape and warm air to enter the cabinet causing a frost or ice build-up around the door. Also, the compressor has to work harder to keep the unit cool. Door gaskets that have become torn or have hardened with age will do the same thing. They must be replaced.

*Condensation on the outside of the cabinet occurs because the door gasket is leaking cold air at that point or because insulation within the cabinet has shifted out of place.*

Magnetic gaskets being used on the newer refrigerators have eliminated the

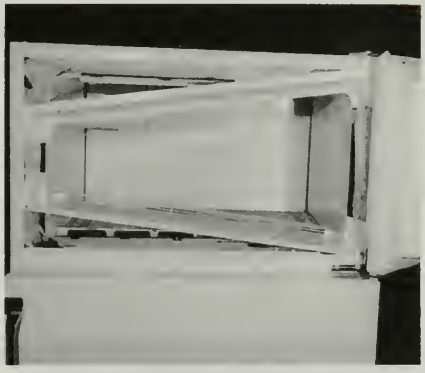



*The evaporator, the part of the refrigeration system that absorbs heat inside the cabinet, is often located behind a panel on the rear wall of the freezer compartment, as is this one. Another common location is between the freezer compartment and the refrigeration compartment.*

*Once the evaporator cover has been removed, the defrost heater can be tested for continuity.*

*The defrost timer is often located behind the plate under the door. It should be set to the correct time of day when it is installed and reset after any power failure.*

*It is necessary to remove the breaker strips to get at some of the wiring between the controls and the compressor. The breaker strips are the plastic strips that form the frame around the refrigerator opening. Usually they are snapped in place and can be removed by using a putty knife to push the strip away from the metal shell and prying outward. They break easily, so be very careful when prying them out or when snapping them back into place.*



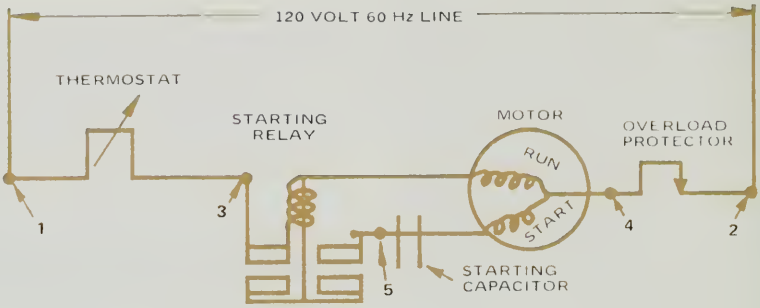
door latch problem and allow a certain amount of door misalignment without cold air leakage from the cabinet. Make certain this seal is not cut or torn. The simplest test for proper door seal fit is to close the door on a piece of paper; then draw the paper out from the seal. There must be an appreciable drag as you pull. A piece of paper the size of a dollar bill would do very nicely.

Inside the cabinet there must be room for the air to circulate, to allow all of the interior to attain the same temperature. The acceptable temperature range in a refrigerator is from 35 to 45 degrees F. In the freezer compartment, temperature should range from 0 to 10 degrees F.

Many of the combination refrigerator-freezers have a fan that circulates cold air from the freezer area through the refrigerator section. Thus, if the freezer section is cold but the refrigerator section is not, make certain the fan is operating and that the air ducts have not clogged with ice. If the fan is defective, it must be replaced. If the duct is clogged with ice, the machine will have to be unplugged to allow the ice to melt.

A defective defrost heater or defrost timer, in refrigerators that have such parts, could cause an ice build-up on the evaporator or in the air duct. The defective parts would have to be replaced.

*Electrical.* The key to understanding the electrical system is being able to interpret the wiring diagram that is attached to the back of the appliance before it leaves the factory. Every refrigerator having a compressor must have a motor to drive the compressor and a thermostat to stop and start the motor at the proper temperatures. Also necessary are a relay in the motor circuit that automatically disconnects the start winding when the motor attains its proper operating speed and an overload switch that shuts off the electrical power when the motor overheats. This could happen if the line voltage were low, or the condenser were covered with dust and not doing its job, or if a defect occurred in the compressor that would make the motor work harder than it is supposed to. This is the basic circuit that operates the compres-




Basic refrigeration compressor motor circuit.

*Use an AC voltmeter to test the basic compressor motor circuit from point to point as indicated in the chart. The motor run and start windings can be tested with an ohmmeter. Each must show a low resistance reading. An open circuit will read ∞ (infinity) and means the winding is defective. The capacitor should show a momentary reading, then drop to ∞ (infinity). No reading, or a stable resistance reading, indicates a defect.*

**BASIC CIRCUIT CHART**

| Test Points | Reading 120 Volts | Reading 0 Volts |
|---|---|---|
| 1 and 2 | Power is available | No power to circuit |
| 3 and 2 | Thermostat is on | Thermostat is off or open |
| 3 and 4 | Overload is closed (has not shut off motor) | Overload is open (has shut off motor) |
| 5 and 4 | Start relay and run winding are functioning | Defect in start relay or run winding |

sor. Whenever the refrigerator fails to operate, check this part of the circuit first.

With your voltmeter or test light follow the test sequence shown on the Basic Circuit Chart. This should allow you to locate the defective part. All parts are relatively easy to replace except the compressor motor. Servicing this requires special tools and replacing it is expensive. A request for a quote on compressor replacement to the local dealer for your make and model refrigerator would be in order. This may also be the time to consider the age of your unit, the repair costs and the price of a new refrigerator.

While the compressor circuit is the electrical heart of a refrigerator, many other electrical parts, controls and improvements have been added to make the refrigerator more convenient to use.

Use your voltmeter or test light to determine whether a part such as a light, heater or motor is getting voltage. If it is and still does not work, use the ohmmeter to test the part for continuity. CAUTION—before using an ohmmeter make certain that the machine is disconnected from the power line. The ohmmeter can also be used to determine if a switch or thermostat is making contact or if the defrost timer switch is in the defrost position.

Always make certain you know what position the defrost timer is in while testing the refrigerator. Some defrost timers are in the defrost position twice a day for 20 minutes, others three times a day. A timer that remains in the defrost position too long raises the temperature inside the refrigerator too much and could cause melted ice

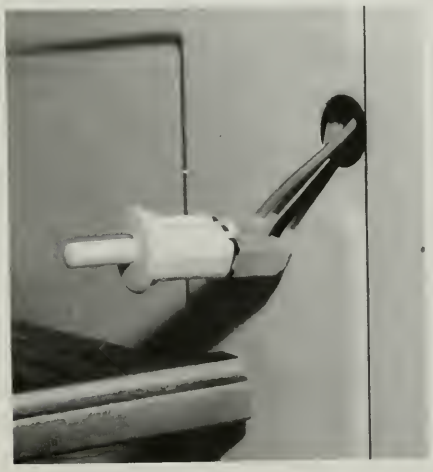
WHERE TO LOOK WHEN THINGS GO WRONG

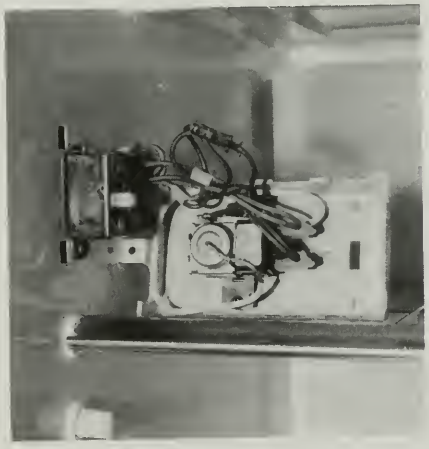
| PROBLEM / POSSIBLE CAUSE | BLOWN FUSE | LOOSE CONNECTION | THERMOSTAT "OFF" | DEFECTIVE THERMOSTAT | DEFECTIVE MOTOR | DEFECTIVE START RELAY | DEFECTIVE COMPRESSOR | REFRIGERANT LEAK | REFRIGERANT STOPPAGE | THERMOSTAT STUCK "ON" | INCORRECT THERMOSTAT SET | DEFECTIVE DOOR SEAL | DIRTY CONDENSER | HOT LOCATION | LOW LINE VOLTAGE | DEFROST TIMER | DEFROST HEATER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DOES NOT RUN | √ | √ | √ | √ | √ | √ | √ | | | | √ | | | | √ | √ | |
| DOES NOT GET COLD | | | √ | √ | | | | √ | √ | | √ | √ | √ | √ | √ | √ | √ |
| GETS TOO COLD | | | | √ | | | | | | √ | | | | | | | |
| EXCESSIVE FROSTING UP | | | | | | | | | | | | √ | | | | | √ |
| MOTOR RUNS TOO LONG | | | | | | | | | | √ | | √ | √ | √ | √ | | |

cream and ice cubes in the freezer compartment.

The accompanying trouble diagnosis chart can serve as a guide to where to start looking for the trouble indicated by the listed symptoms. G.M.

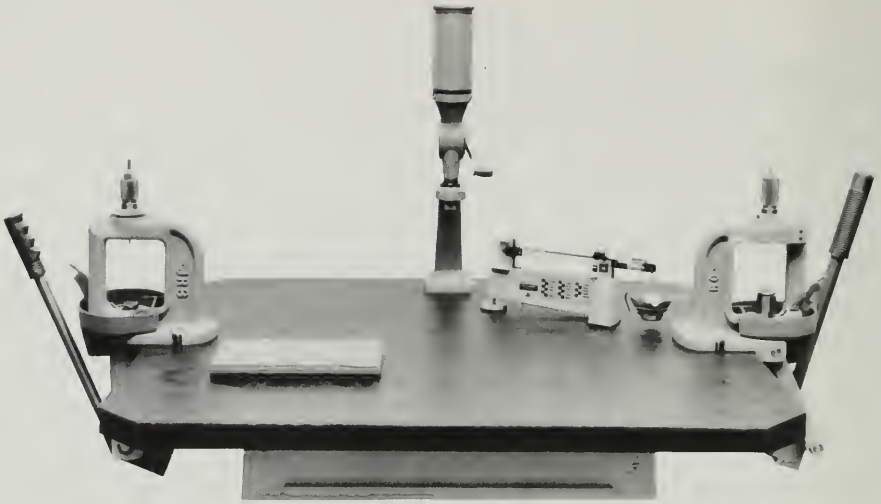
*See also:* APPLIANCE REPAIR; ELECTRICITY; INDIVIDUAL APPLIANCE LISTINGS.





*The thermostat is often mounted in a plastic housing held in position by two screws or a snap-in type fastener. Unfastening the housing from the cabinet will expose the wiring and sensing element.*

*The door switch controls the cabinet light and fan system. It usually is snapped into place and can be pried out with a screw driver or putty knife.*



*Ready for reloading shells, bench is stripped to essentials for fast, safe work.*

# Reloading Ammunition for Your Weapon

## Use this trial-and-error system to tailor your ammunition for best performance

RELOADING CAN INCREASE the accuracy of your rifle, pistol or shotgun, but only if it is done expertly.

Each firearm is a law unto itself. The combination of barrel, action and stock contains so many variables that it is impossible to predict precisely their effect on any given load. Then, variables in the cartridge also have their unpredictable effect. However, there is usually a combination of powder, bullet and primer that will perform best in each specific weapon.

Let's say you want the best 180-grain bullet load to shoot an elk this fall with your 30-06 Springfield. For a starter, if a Speer manual is handy, select the Speer bullet and DuPont 54350 powder. That is normally a good combination, one that can drive the bullet at over 2700 feet-per-second. You will start, of course, with less than the listed maximum, 56 grains of powder. Load up ten rounds with 54 grains then another ten each with 55 and 53 grains. That 53 grain load does not look impressive on paper, but if it hits your elk where you hold, he'll never know the difference.

Take those three different loads out to the range or to the nearest safe place to shoot. If you have a bench rest, use it. If not, don't feel handicapped. Take along your bedroll, or lacking that, just make up a fairly solid roll of blankets a foot or more in diameter. Use it as a rifle rest. From a good, solid prone position, shoot two five-shot groups with each load. Take your time. Do not shoot so fast the barrel gets all heated up. Do try to get every shot off when wind and light conditions are the same. Shoot the very best you know how. If you have a buddy or acquaintance who is a better shot than you, it will be worth your while to have him give you a hand. Remember, this is a test of rifle and ammunition, not a test of your personal skill.

**reluctor lobe:** see ignition system, auto
**remodeling, bathroom:** see bathrooms
**remodeling, garage:** see garage remodeling
**remote audio control:** see intercoms

One of those loads will undoubtedly shoot groups at least a bit smaller than the others. If it's the 55-grain load, make up ten more rounds with 55½ grains, and another ten with 54½. Shoot them. It may be that neither will do any better than the 55-grain charge, but then again, one of them just might do better. The point is, you will not know unless you try them. Now, if the 54½-grain load does the best, it is your load. There is no doubt about it, because it shot more accurately than loads ½-grain above and below it. If, on the other hand, the 55½-grain charge performed the best, you have still got a bit of work to do—the reason being that you have not yet tried a heavier charge. Go up a half-grain and try ten rounds. If accuracy is better, then that's your load. You cannot go any higher in charge, because that would take it over the maximum listed in the manual. Never exceed that. If, however, no improvement is evident, then you have confirmed that the 55-grain load is best.

In all this process you may have consumed 50 to 100 bullets and a pound or more of powder. But you have determined, to a degree, exactly what load produces the best accuracy in your specific rifle. It may not shoot as well in a neighbor's identical weapon, but in yours it gives you the best possible chance to hit your target. There is certainly no point in sending yourself out into the cold, snowy mountains to hunt unless you have done everything possible to make certain the rifle shoots as close as possible to where you aim. From that viewpoint, the cost of the components might well mean the difference between success and failure. It is not a bad bargain at all.

Load development can stop right there, and more often than not it does. But further refinement is usually possible, requiring but a little more time and money.

The next logical step is to use that "best" powder charge as determined above with other makes and types of bullets of the same weight. So let's load up ten each 180-grain Sierra and Hornady bullets. If either produces better groups than you got with the first bullet, it is naturally the one you should use. If that is the case, and one of the new bullets is the best of the three, then perhaps a bit more refinement of the powder charge will produce even better accuracy. Simply load up two more test batches, a half-grain above and below the charge just used. If any improvement is noted with either charge, then the one producing it is the logical choice for serious use.

But, you say, what if all this testing does not really produce significantly better accuracy? You've got a problem if that happens—but not an insurmountable one. Since you have varied bullet make and powder charge weight only, the next logical step is to try another powder. There are several that are suitable for use with the 180-grain bullet in the 30-06 case. DuPont 4320, 4064, Hodgdon's 4831 and H-450 will all produce much the same velocities. You simply pick the next powder in line and start all over, teaming it up with the bullet that has grouped the best up to this point. Even the most recalcitrant rifle will respond to such continued treatment to some degree.

While one might encounter a rifle that simply won't group satisfactorily with any load, the chances of running into one are slim. But if it does happen, don't hesitate to take it along to the best gunsmith in your area before condemning it completely. In such a case, there is probably something wrong with the stock bedding which is not at all difficult to correct. Once the deficiency is corrected, you can safely proceed with your load development.

At this point, having varied bullet make, powder make and weight, you have really covered the most important things. However, it is still possible to refine loads even further. Modest variation of bullet seating

depth has been known to result in improved accuracy. Changing the seating depth changes the relationship of the bullet to the lead (beginning of the rifling), and also changes the amount of air space in the case. Both factors affect pressure and velocity to some extent, so can cause accuracy to vary. It is not possible, though, to predict whether accuracy will get better or worse when such changes are made. You simply make them, then shoot to see what happens.

With a load intended purely for target or varmint use, where magazine feeding is not essential, accuracy can often be improved by seating the bullet far enough out of the case to very nearly touch the leade.

After bullet seating depth, there is still another factor that can be varied. Primers are not all identical, though the different makes are far less different today than they were in the days before World War II. There are differences, and sometimes changing from one make to another will produce better (or worse) accuracy. In large capacity cases loaded with slow-burning powder, magnum primers will often produce the better accuracy. In the smaller cases, or with faster powders, standard primers will usually do best.

While pistol load development is essentially identical to that for rifles, it is worth a few special comments. One area often neglected is that of working up loads for fixed-sight guns. Most published loads will not shoot to the same point of impact as the commercial ammunition for which the gun was targeted at the factory.

Let's say you have a four-inch barrel .38 Special of popular make, fitted with standard fixed sights. It was targeted with commercial 158-grain, round-nose, lead bullet loads, the front sight being trimmed to compensate for both jump and drop of that load. If you attempt to use a heavier bullet at the same velocity, or the same weight bullet at a higher velocity, the gun will shoot high. This is due to greater jump of the muzzle before the bullet leaves the muzzle. Conversely, lighter bullets will shoot low, even though driven considerably faster than the load for which the gun was targeted.

By careful experimentation with powder charge and bullet weight, it is possible to bring point of impact quite close to point of aim. The rules for doing so are pretty nebulous and flexible. Essentially, heavy bullets will shoot high, light ones low. Anything that increases recoil whether it be more velocity or more bullet weight, or both, will raise the point of impact. The reverse is also generally true.

These rules limit the loads that will hit point of aim. It is patently impossible to develop an ultra-light wad-cutter load that will hit where the gun looks. Thus, if you want to do light-load practice with your six-gun, you should get it fitted with adjustable sights.

Following the same rules, it is possible to zero a six-gun (or an auto-loader) for any reasonable range by varying the load. Just remember—more recoil shoots higher, therefore line-of-sight will intersect trajectory at a greater distance from the gun. Many competitive shooters utilize this principle, even with heavy target guns fitted with adjustable sights. To avoid frequent sight changes between 25 and 50 yards,

*Kit contains everything for proper case lubrication. Bullet lubrication is important for top handgun accuracy. Try several and select the lubrication that suits your gun the best.*

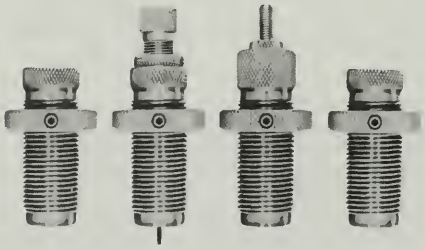
they simply brew up separate loads that will hit the same point of aim at the two ranges.

Another factor often ignored in developing accurate loads for handguns is bullet hardness. Many guns are a bit temperamental about this. Your best bet is to use lead alloy of known hardness, then vary it in known amounts until you find the degree of hardness that works best. Special care must be taken during this sort of development to make certain that the bullets are perfectly cast, without airholes or other imperfections. Do not buy scrap lead of unknown content.

Bullet lubrication is another factor in getting the best accuracy out of a handgun. While almost any lube will produce acceptable results, a few extra points can often be gained by trying several different brands to select the one that suits your gun best. If you are really enthusiastic, you might even try to brew up a few batches of your own, but it is doubtful that you'll be able to improve upon the products of professionals.

This is a good a time to point out that everything said about lead bullets applies even more to rifles than pistols. In the use of lead bullet reduced loads in rifle calibers, bullet hardness, lubricant, and bullet diameter produce profound effects. Where a revolver might do equally well with bullets measuring .001-inch and .003-inch over barrel groove diameter, a rifle might perform superbly with one (and it could be either), yet not stay on your hat at fifty yards with the other. Just remember that with lead bullet loads, even the slightest variation can make or break accuracy. Leave no stone unturned if you want top results. The old-timers with their fine, superbly accurate Schuetzen rifles often spent many months and many thousands of rounds in developing the perfect lead bullet load. Some of them even went so far as to use different loads according to the seasons of the year—the load that performed best in hot, dry summer being quite different from the one best for cold, damp winter shooting.

*Operator of this double-use bench for rifle, shotgun and handgun cartridges can boast of no needless equipment.*



*The ultimate in pistol loading can be accomplished with this four-unit die set. Enhance your success and pleasure with your guns by developing the best loads for your use.*

Regardless of the use to which you will put your guns, your success with them and the pleasure you get from their use will both be considerably enhanced once you have learned to develop loads best for your own use. Load development as a separate art is one of the most fascinating and most useful phases of reloading. When new guns and factory-loaded ammunition are hard to come by, it enables you to get the most out of what you have.

*See also:* HUNTING; PATTERNING, SHOTGUN; SHOOTING; SHOOTING TECHNIQUES; SHOTGUN; SHOT SHELLS.

# How to Hand Load Ammunition

**In addition to the pleasure it gives some hobbyists, hand loading can, under some circumstances, save money and improve the accuracy of a weapon**

THERE ARE FIVE reasons for loading your own ammunition:

1. To save money.
2. To improve accuracy or ballistics.
3. To adapt a gun to a specialized use.
4. To provide a wildcat caliber that is not available commercially.
5. To do it simply for fun.

Most hand loaders do it to save money. Just how much you can save depends upon the quantity of ammunition loaded, how much you pay for your empty cases and what calibers or gauges you deal with. Cost of original loading equipment is a consideration too.

If you are loading shotgun shells and are able to find plenty of empties free, you should be able to load for one-half the cost of factory shells. This means you would buy primers, wads, powder and shot. If you plan to load in large quantities or go into hand loading on a club basis, your costs would be reduced even further.

High-powered rifle ammunition can be hand loaded for about one-third the cost of factory ammunition, providing you have empty cases. Repeated use of cases is what really brings costs down. If you build hot hunting loads, cases may not last long. If you load mildly, they will last for 20 or 30 reloadings.

Your biggest cost in high-powered rifle loads is the jacketed bullets. If you cast lead bullets, the cost really drops but such

bullets are usable only in reduced loads and are not recommended for "bear busting."

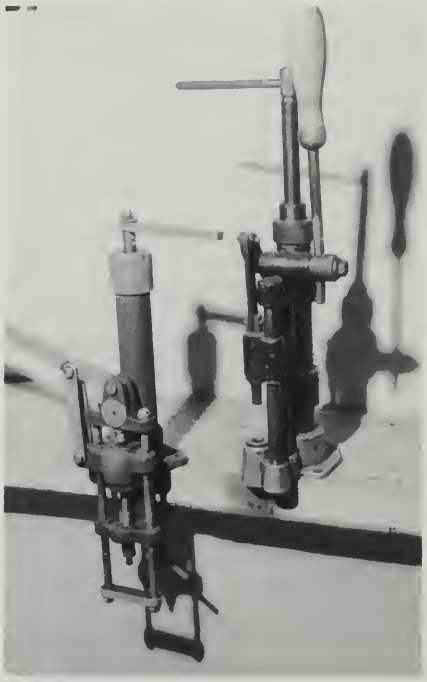
Hand loaded pistol ammunition of the target variety is inexpensive. It requires only a little powder and the lead alloy requirements are not exacting. By scrounging lead here and there, many target shooters grind out .38 caliber pistol ammunition for less than a cent a shot, not counting the empty cases. When you start making full-charge hunting ammunition for pistols you are into a much more complex field.

Improving accuracy or ballistics is easy if you are the experimental type. No two barrels are exactly alike. One shoots better with a bit more powder or a bit less. One prefers a heavier bullet and likes a special brand. New shotgun barrels pattern differently and yearn for a particular powder and wad combination or for a certain shot size.

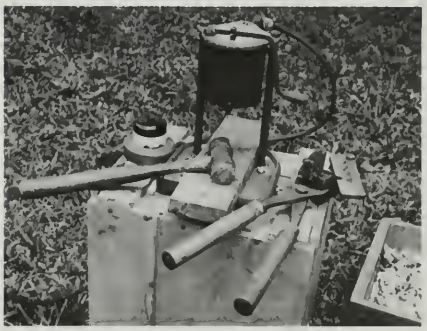
If you are working with a rifle, a few hours at a bench rest probably will prove you can improve on factory results, but not necessarily. It is always possible that a factory load is just what your pet rifle prefers.

The shotgun load variations are almost endless, but almost every shotgun is less efficient with some combination of shot, powder and shell. Find the perfect combination for your particular nozzle and you can actually increase killing range.

*Some varmint shooters hand load in the field with compact tools. More complex loading is best done at home.*



*Larger Phelps tool turns out a sized and lubricated lead bullet with one stroke of handle. Cramer tool requires two strokes per bullet.*



*An outdoor setup for bullet casting. Mold is 4-cavity in .38 caliber. Note small furnace.*

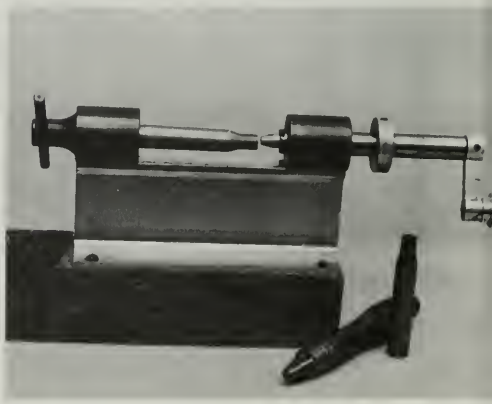
*Accessories for trimming elongated cases. Adjustable trimmer is a Forster. Tool by the shell is for chamfering inside of the case mouth.*

Factory ballistics can be improved in many rifle cartridges. For example, the Remington .280 is loaded very conservatively at the factory, since semi-automatic and pump rifles are made for it. Using a good bolt action, one can increase its powder considerably and still have a load with mild pressures by bolt action standards.

Two other classic examples are the .270 Winchester which until recently could not be had in a factory load with a pointed 150-grain bullet, and the 7 mm. Mauser which has been handicapped in America by a heavy, round-nosed, 175-grain brush bullet. A pointed or spitzer bullet in 150-grain is a salty, long-range big-game load for the .270 and there are plenty of lighter, fast bullets that will work in the 7 mm., making it a fine, light, long-range rifle.

With the good bullets available from American manufacturers, you can have almost endless variety with a single rifle. In fact, a realistic examination of all the possibilities might reveal that some of the new calibers could be virtually duplicated by an old standby.

In adapting your gun to specialized use, consider the popular stunt of big game hunters who load up light small game loads to carry along with their full charges. With the light loads (and often with cast



*You can make a box of 20 rifle cartridges with this set. Components are case, powder, primer and bullets.*

*Accessories like these can make hand loading more efficient and more fun. Make sure that you have a loading guide.*

*Handy for traveling shooter, this entire set for making high-powered rifle calibers fits into military ammunition box.*

lead bullets) they can collect grouse or squirrels for the pot without too much meat destruction and with mild report. Lots of experimenters produce squib loads that are on target at short ranges while the hot stuff will hit away out.

Some weapons (usually "wildcats") do not accept any commercial ammunition. Although the rash of new rifle calibers pretty well covers the field, some enthusiasts still feel a wildcat fits their particular needs. Only hand loading can provide the ammunition. Users of obsolete old-timers may have to depend on hand loading too.

As to the reliability of hand loaded ammunition, it is about the same as factory made, if carefully prepared. Failures of homemade loads are usually the result of cases that have been used too many times or components that have been poorly cared for or are overaged.

For big game hunting, the hand loader should stick to new or nearly new cases and should try the loads through the action of his gun before the trip.

Wild experimentation can, of course, produce poor or dangerous loads. There are some excellent manuals for hand loaders. Every sensible shooter should begin with mild loads and work up, if he wants maximum velocity. Generally the most accurate load is not the maximum pressure a rifle will safely hold, and excess pressures can be noted in several ways. If conservative, the hand loader will never see any indication of stiff pressures.

Hand loading is about as dangerous as filling a car with gasoline, if you follow the instruction sheets. Do not smoke while loading.

If you are careless it is possible to load a double charge of some kinds of powder, although two charges of many types will not go into the case.

The first safety rule is to concentrate on what you are doing, and do not do it in a hurry. Keep notes of charges and methods, and try to stay out of spirited conversations while engaged in making ammunition.

A complete stranger to hand loading could take a simple set of loading tools and be making excellent rifle or pistol ammunition within the first half hour if he follows the directions. Shotgun loads are only a bit more complicated.

Cost of equipment can run anywhere from $15 and up. To make rifle ammunition all you would need would be a reloading outfit, empty cases, primers, powder, bullets and a plastic hammer or stick of hardwood.

Bullet casting complicates things somewhat. It can be a little messy. But you could do the actual loading in the living room, if you wanted to.

The Lee rig, which is very nearly revolutionary, is hard to beat for the fellow who wants to load small quantities of cartridges. For example, if he only wanted 20 or so, he would probably have them loaded with the Lee before he could get into action with a larger tool. For high-speed production and greater variety of loads, a more substantial setup would be necessary.

Lyman produces the inexpensive Ideal tong-type tools which have been used for many years and are reasonable in price. These small tools have only one shortcoming in rifle use. They do not full-length resize the case. Full-length resizing is not advisable where it can be avoided as it works the brass to excess and shortens case life. However, it is occasionally necessary with some calibers, especially when the cartridges are to be used in pump, lever or semi-automatic arms or when the same cases are used in two or more rifles.

Bench-type tools accepting one die at a time are practical for most rifle or pistol reloaders. Generally one die is used to remove the spent primer and to size the case (usually only at the neck), opening the mouth of the case slightly. The second die seats the bullet after the powder has

➤ *Discards, left to right: split case; wadcutter .38 bullet that was forced off center into case; shotgun case that has given way through repeated reloading.*

been introduced. There are some 3-die sets in favor for pistol cartridges. A single resizing die can be used for both neck and full-length resizing rifle cases through slight adjustment. A few rifle sets have three dies, a separate die being provided for full-length shaping when needed.

A blizzard of new shotshell reloaders are on the market, and they are being made simpler all the time.

Anyone who fires a lot of shot shells can save with a loading tool. One catch in shotgun shell reloading is that various shells require different wad columns and a mixed pile of empties will require a lot of sorting as well as some careful wad column arrangement. This means you will have to keep quite a pile of wads on hand to do the job right.

If you are reloading shot shells purely for economy reasons it may be you will prefer factory ammunition for serious hunting, using your own shells for practice.

Some shooters do their reloading from odds and ends of empties they have picked up from dove fields. For their informal trap and skeet shooting, and for dove hunting, they use hand loads. For waterfowl, they use factory ammunition, figuring the express loads are too much trouble to set up for—and they do not burn up so many anyway.

Among the accessories that contribute to reloading speed and pleasure are a good set of powder scales (almost a necessity if you are using several charges), a powder measure (which can be set exactly by reference to the scales), loading blocks for holding rifle or pistol cases, a case trimmer (used on rifle cases after repeated reloadings which cause necks to stretch), case lubricant and a bullet puller (for disassembling rifle or pistol cartridges).

If you cast bullets, a lead furnace is a big help. Gang bullet molds speed things up, but do not go overboard on the largest molds available. They are very expensive and require special care to keep from warping. They are hard to keep at uniform temperatures, and are best used only by loaders really engaged in quantity production.

The big, automatic loading machines cannot be beaten for quantity production, once you have standardized. C.F.W.

*See also:* HUNTING; PATTERNING, SHOTGUN; SHOOTING TECHNIQUES; SHOTGUN; SHOT SHELLS.

➤ *Bedside master selector switch controls lights all over house.*

# Low-voltage Remote Control Switching

**All you need to enjoy the convenience of remote control over your house's lighting are a master panel, special 24-volt wire, relays and possibly some switch motors**

REMOTE CONTROL low-voltage relay switching can add to living convenience, and to the market value of any home. Yet remote switching has been bypassed by many do-it-yourselfers because of a mistaken belief that such wiring is either complicated or tricky. Tricky it is not, though it can become complicated if an entire home is wired to take full advantage of the many unique control features that are possible. In such cases, the amateur electrician will do well to obtain professional assistance. However, simpler installations that meet most home needs are well within the capabilities of the average home handyman.

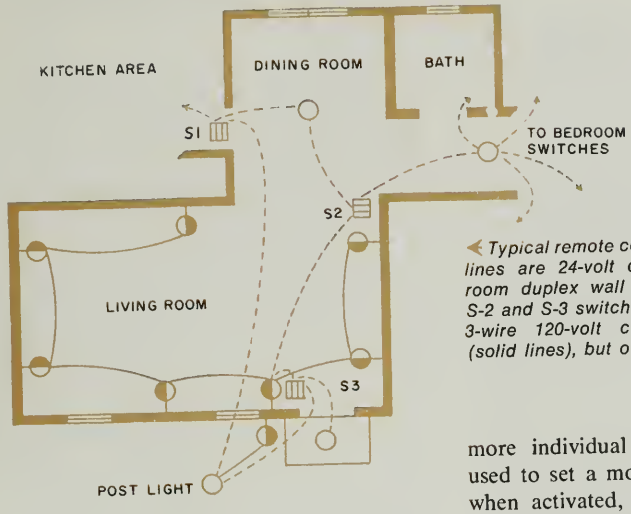
What is so great about remote switching? Mainly economy, safety and convenience as compared with conventional systems.

Remote switching systems require the use of special relays, switches and a transformer. Yet these costs are often more than offset by savings in the purchase and installation of conventional armored (BX) cable—especially when remote switching is used in lieu of conventional three-way and four-way switching systems.

The safety of remote low-voltage switch-

**removal, spot:** see spot removal
**removers and bleaches:** see finishing, wood
**repair, appliance:** see appliance repair

*Low-voltage Remote Control Switching*




*Typical remote control switching setup: dotted lines are 24-volt circuits. Half of each living room duplex wall receptacle is controlled by S-2 and S-3 switches; such split wiring requires 3-wire 120-volt cables between receptacles (solid lines), but offers many advantages.*

ing is obvious since the wiring in switch boxes carries only non-lethal 24-volt currents, not the usual 120 volts. Moreover, lockout circuits can be added for extra protection of children.

The big plus is use convenience. A single switch can turn on one light or many. Or a single light can be controlled from many different locations; for example, a hall light can be operated from the living area, bathrooms, and all bedrooms. No need to fumble and stumble in the dark when bedside switches can create a path of light through the entire house, even before you put your feet on the floor.

Master selector switches are usually placed in the garage and master bedroom in a deluxe wiring system. These not only provide paths of light, but permit turning off all lights when leaving the home or retiring for the night; or they can be used to flood the house and grounds with light to scare off prowlers. There is no need to wander all over the house to turn on lights one by one.

Special motorized master switches provide added convenience because they reduce switch flicking to a minimum. One or more individual master switches can be used to set a motorized unit in operation; when activated, it can automatically turn as many as 25 circuits on or off in moments.

*Typical applications.* How you might wire the living/dining areas of a new home is shown in the wiring drawing. Similar wiring plans would apply for wiring you might add to a basement recreation area, or to a new wing being added to your home. Note the great degree of switching flexibility that is achieved without the use of armored cable. The dotted lines represent low-voltage conductors that are much easier to install than would be conventional wiring.

Split-wiring of wall receptacles offer almost mandatory advantages although it calls for use of three-conductor power (120V) cables between the different outlets. When split-wired, only half of each duplex outlet is switch controlled for turning lights on and off. Clocks, radio and television sets are plugged into the unswitched halves of the receptacles. Outdoor outlets are also split-wired to advantage. For example, Christmas lights plugged into the switched outlets can be controlled from inside the house.

When you plan the new wiring, consider the advantages of locator-light switches (easier to find in the dark) and of pilot

type switches that let you know whether remote lights (attic, for example) are on or off. Just remember that a pilot switch also requires a special pilot relay and four-conductor wiring.

*Positive control.* Two-wire remote switching systems used in the past were often plagued by erratic switching action. Modern three-wire systems are far more reliable.

A simplified diagram of a basic switching circuit is shown in the wiring diagram. Note that the relay (located in the outlet itself or in a central relay box) consists of two parts —the low-voltage solenoid section, and the high-voltage switch section controlled by the solenoid The solenoid consists of a coil tapped in the middle with a third lead so that only half of the coil is activated for On switching, the other half for Off switching. When a 24-volt current pulse flows into either half of the coil, the solenoid armature is drawn into that part of the coil. This either makes or breaks the 120V current through action of the bus bar indicated with square terminals.

Both On and Off switching is a positive action. Neither depends on any sort of spring return action. Only momentary depression of the wall switch is needed to activate the relay. The 24-volt switching current does not continue to flow through the wall switch after switching has been completed.

Incidentally, since all switching action is accomplished by brief electrical pulses, a single transformer will probably serve all your low-voltage needs—unless you install many locator or pilot type switches.

One switching system will operate with 24-volt AC current delivered by the transformer. But switching action is smoother, and there is greater systems protection, if the rectifier is added to convert the AC current to half-wave 24-volt DC. Both silicon and selenium type rectifiers are available for this purpose.

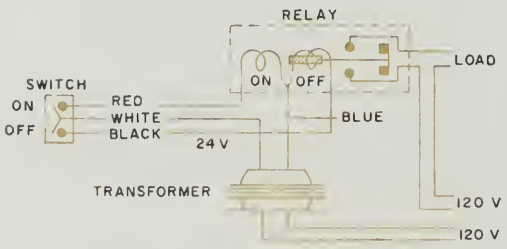
*Relay locations.* Each relay can be located in the outlet box it serves. Or many relays can be massed in central relay boxes. Each method has advantages and disadvantages. Relays located in the outlets may be more difficult to service, and you may hear the switching action though it should not be objectionable. If you group the relays in one or more central boxes, they can be serviced with ease, and switching in the house will be completely silent.

Relay boxes are perhaps best located near the service entrance, or they may be put into the attic or basement. In any case, the use of relay boxes usually means that you will have to install some extra armored high-voltage cable to connect the relays to individual outlets. The average do-it-yourselfer will probably elect to minimize BX wiring by putting the relays into the individual outlet boxes.

*Coded wiring.* The use of color-coded wiring will enable you to keep track of what goes where. The color coding shown in the diagrams is that recommended by one manufacturer when using their products.

Two-conductor wires are used to connect the transformer to the relays, three-conductor wires are for wiring individual switches to the relays. Four-conductor wires are required for switches having pilot lights. Cables having 12, 19 or 26 conductors are

*Basic circuit with relay in off position. When switch is turned on, electricity flows in white-red-blue circuit, and energizes left half of relay winding. Solenoid armature is pulled to left, closing 120-volt relay contacts (square terminals contact round ones). When off button is pressed, the solenoid action is reversed by white-black-blue circuit, and the 120-volt circuit is opened.*



required when installing master selector switches.

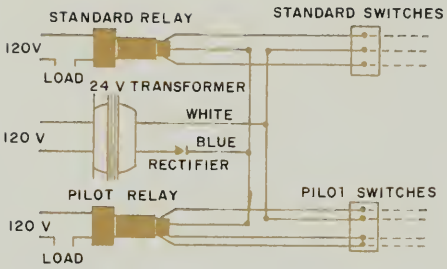
The wires should be stapled to wall studs and ceiling beams using tackers made especially for installing electric heating wires and cables. Do not use a stapler that takes only flat, sharp-edged staples used for other purposes; these can cut through wire insulation and cause short circuits.

Usually, the low-voltage wiring can be easily snaked through existing walls. Often even this is not necessary. You can install the wires behind baseboards or moldings; or you can gouge grooves into walls and imbed the wires with plaster.

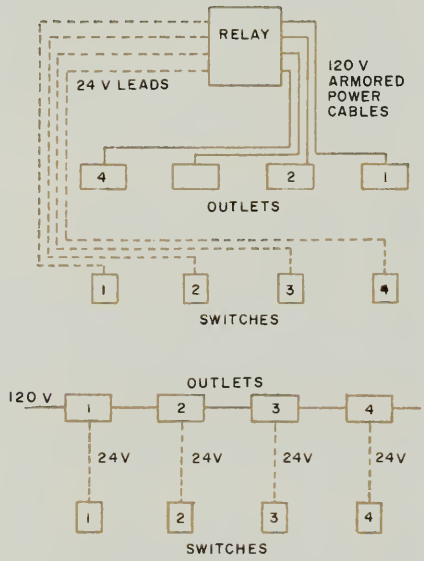
*Important dont's.* Your transformer will probably handle all switching problems with ease since it won't have to deliver a continuous current except to power pilot and locator lights. Even a master switch creates no overload problems because the multiple switching actions are sequential, not simultaneous. The only time you need worry about possible overworking of the transformer capacity is if you connect several relays in parallel for simultaneous action.

Do not connect two or more relays in parallel if they must also be operated independently unless you use special circuitry (obtain instructions from your materials supplier or manufacturer). Also, avoid connecting two motor master units in parallel because the current used by one motor may be enough to keep the other running past its normal shut-off position; thus two parallel wired motor masters might run continuously. Likewise, do not use locator-light switches to operate motor-master units; the locator lamp may also keep the motor running continuously.

Simple remote switching circuits are easy to install. But if you plan extensive low-voltage wiring, consult Article No. 725 of the National Electrical Code, and your local electrical inspectors, to make certain at the outset that you will conform with all regulations. It may be low-voltage, but it is still electricity and there are rules to be observed.




*Use of pilot lights requires 4-wire conductors, special pilot relays (bottom). Standard switches use only three wires. Note position of optional rectifier which is somtimes used to smooth switching action.*




*Central relay box offers some advantages such as ease of servicing, but usually calls for the use of more armored 120-volt cable. Installation of relays in individual outlets simplifies wiring for the do-it-yourself home electrician.*

*See also:* CIRCUITS, ELECTRICAL; DIMMER, LIGHT; ELECTRICITY; LIGHTING; WIRING, ELECTRICAL.

# How to Spot That Noise and Quiet It

**That squeak, rattle or thump may mean your car is trying to tell you something. Here's how to listen—and understand**

WOULDN'T YOU LIKE to choke that little "canary" somewhere in the front end of your car that's been pestering you? Or, maybe you've got one of those thumpy clunks that only shows up now and then at certain speeds. Suppose your car runs like the proverbial jack rabbit but when you hit around 45 or so, some sort of a howl or wheeze comes in that makes your passenger ask, "What makes it do that?"

Noises often come from a source least expected as knocks, growls, groans, squeaks, whistles and so on and have a way of seeming to be where they aren't. Even the best shops are often stumped by odd sounds, especially when everything seems to be tip-top. There is always that "mysterious" knocking or rattle, hard to pin down. But even the most evasive squeak can be located by following these methods.

Unwanted noises plague new and old cars, big and little cars. Those little tingling noises that are often heard only when the car is in motion can keep you guessing. And for the life of you, you can't reproduce them by bouncing or shaking your car. Weather has a lot to do with car noise too. Some squeaks and rattles ride with you on hot, dry days but fade away during rainy weather. Sometimes all you can do is localize foreign noise, and you would have to tear down the unit to find the cause, like a transmission, for example. You may have traced a low speed "howl" to a manual transmission. Tearing down the transmission might show a defective clutch pilot bearing, binding clutch hub or misalignment of the clutch in the flywheel as the direct cause of the growl.

While a complete chassis lubrication, including under hood engine units, stops many noises, don't depend too much on a chassis lube job to take care of the squeaks and groans permanently. There may be a worn spring shackle that quiets down with a lube job, but lubricant won't take the place of worn rubber or metal. Once you've traced such a noise, better get some new bushings in the shackle. Higher car speeds and more powerful engines tend to amplify

**resorcinol resin glue:** see adhesives
**retaining walls:** see stonework
**reupholstering:** see furniture, used
**rocking chair:** see furniture, outdoor
**roll-about server:** see servers

## TABLE A

### ENGINE AND UNDERHOOD NOISE

| CHARACTERISTIC SOUND OR BEHAVIOR | PART OR PARTS AFFECTED | PROBABLE NATURE OF TROUBLE | CHECKING | REMEDY |
|---|---|---|---|---|
| Hissing | Spark plug | Broken or loose | Squirt oil around plug base; bubbles indicate leak | Tighten or replace plug |
| Click or rattle | Fan | Bent blade, loose pulley | Look for shiny spot on blade. Inspect pulley | Replace fan—do not sraighten. If problem is caused by weak engine mounts, replace them, too |
| Loud report in muffler | Muffler | Exhaust valve not seating. Ignition out of time. Rich or too lean mixture | Accelerate engine for smoke from exhaust pipe | Reface & regrind valve. Retime ignition to engine. Clean carburetor jets or adjust fuel level |
| Sharp snap Engine pulling | High-tension Ignition System | Cracked distributor head. Cracked plug insulator. Damaged wire insulation. Loose distributor wire | Wipe distributor head and plugs. Examine wire insulation. Test wires in distributor sockets | Wipe parts clean or replace with new. Tape wires or replace. Push wires firmly into sockets |
| Dull thump or Pound upon acceleration | Engine mount or mounts | Loose or deteriorated rubber in mount | Visual inspection | Tighten bolts of mount or replace rubber blocks |
| Metallic rattle upon acceleration | Muffler or tail pipe | Muffler baffles loose. Tail pipe strikes frame | Use sounding rod on muffler (rear end on jacks) shake tail pipe | Install new muffler. Bend tail pipe and tighten clamps |
| Squeal (generally at idling speed) | Generator Fan bearing Water pump | Generator brushes too hard. Fan bearing dry. Dry water pump seal | Use sounding rod on suspected units | Install new generator brushes—or sand commutator. Lubricate fan bearing. Use soluble oil in cooling system |
| Knock (upon accelerating or pulling) | Ignition Distributor | Automatic advance stuck. Spark timed too early. Vacuum control not functioning | Test governor weights for free action. Check timing with a timing light. Check vacuum control | Clean and lubricate governor advance. Retime ignition to engine with timing light. Install new diaphragm |
| Intermittent rap (engine idling) | Crankshaft | Excessive end play in crankshaft | Noise affected by applying or releasing clutch | Install new end-thrust bearing or bronze washer |
| Loud knock or "bump" (engine pulling hard at low speed) | Crankshaft main bearing | Loose or worn main bearing | Short out spark plugs with screwdriver on block or head | Replace worn bearing or bearings with new or adjust with shims |
| Well defined knock or "tap" on accelerating more pronounced when releasing pedal | Connecting rod | Worn bearing | Allow engine to "pull" at approximately 35 mph. then release accelerator pedal pressure | Install rod or rods with new bearings |

*Continued*

**TABLE A (Continued)**

| CHARACTERISTIC SOUND OR BEHAVIOR | PART OR PARTS AFFECTED | PROBABLE NATURE OF TROUBLE | CHECKING | REMEDY |
|---|---|---|---|---|
| **ENGINE AND UNDERHOOD NOISE** | | | | |
| Light metallic knock or tap (engine idling) | Piston pin | Worn pin | Hold sounding rod on block from cylinder to cylinder. Short out plugs one by one | Install new pin or pins |
| Decided "slap" or knock with cold engine | Pistons | Pistons loose in cylinder. Connecting rod misaligned. Excessively worn cylinders | See whether noise disappears as engine warms up | Recondition cylinders. Install new pistons, rings, pins and align connecting rods |
| "Spark" knocks (when open throttle) | Ignition Distributor | Sticking distributor breaker plate. Governor advance springs weak | Visual inspection of plate. Test distributor, after removal in test machine | Clean and "free-up" breaker plate. Install new governor springs. |
| "Whistle" (partly open throttle) | Heat riser tube | Loose tube | Idle engine. Remove air cleaner. Hold bundle of rags over exhaust tail pipe. Stop engine. Check for smoke from carburetor air intake | Install new riser tube to replace burned out tube |
| Hissing sound (in crankcase) | Pistons and Rings | Loose pistons or stuck rings causing "blow-by" | Look for smoke coming from breather pipe or crankcase. Insert rubber hose in breather. Crank engine and place ear on other end of hose | Recondition cylinders, new pistons and rings, or free-up rings with solvent |
| **DRIVE LINE NOISE—CLUTCH, TRANSMISSION AND PROPELLER SHAFT** | | | | |
| Chatter | Clutch | Facings worn or glazed | Accelerate car slowly. (also check for excessive end play in rear spring front shackles) | Install new clutch facings. New pressure plate may also be required |
| Grinding noise | Clutch | Worn release bearing. Bearing requires lubrication | Press clutch pedal intermittently | Install new release bearing |
| Squeaks | Clutch | Insufficient pedal-to-floor board clearance | Test for pedal striking floor board | Adjust screw or pedal shaft clearance, to correct specification |
| Whining noise | Fluid flywheel | Fluid level low | Constantly audible | Add fluid to correct level |
| Gears noisy when shifting | Transmission and Clutch | Wrong clutch pedal adjustment | Noise evident when shifting into any speed while pressing clutch pedal | Adjust for correct "lash" and floor board clearance |
| Grinding noise from transmission at high speed | Transmission and Propeller shaft assembly | Worn transmission rear bearings. Worn universal joints | "Whip" of propeller shaft usually can be felt at high speed | New transmission bearings (other parts may be needed too). Renew worn universal |

| | | | | |
|---|---|---|---|---|
| Howl (shift lever in "low") | Transmission (manual) | Worn clutch pilot bearing in flywheel recess | Noise usually disappears in 2nd and high | Remove clutch & transmission assembly & install new pilot bearing |
| Growl or hum (in "neutral") | Transmission (manual) | Pinion shaft bearing and gear probably excessively worn | Depressing clutch pedal usually stops noise | Overhaul transmission (other gears and bearings usually are worn, too) |
| Whirring noise (under car, with considerable vibrating) | Propeller shaft | Worn universal joints and unbalanced propeller shaft | Drive at fairly high speed. Shift to neutral. Let engine idle. If vibration persists, suspect propeller shaft | New universal joint parts (also perhaps, transmission rear bearing) |
| **CHASSIS, SPRINGS, SHACKLES, AND SHOCK ABSORBER NOISE** | | | | |
| Rattle | Under hood chassis parts (front) | Loose radiator shell. Independent coil spring pads missing. Car heater bracket loose | Visual inspection of parts; test for looseness with heavy screwdriver | Replace missing parts, screws or bolts and tighten securely |
| Rattle | Muffler or Tail pipe | Muffler and tail-pipe bracket loose | Grasp and shake end of tailpipe. Visual inspection underneath car | Replace missing parts screws or bolts and tighten securely |
| Drumming noise | Under hood parts | Loose engine mountings | With carburetor throttle rod accelerate engine in short "jerks" and observe engine mountings for movement | Tighten engine hold-down bolts (or replace rubber mounts on newer engines) |
| Heavy bumping noise | Under hood | Battery loose in its cradle | Visual inspection | Tighten battery hold-bolts (also see if cable has been chafing) |
| Dull thud | Spring shackle or bolt | Worn or loose rubber or metal bushings | Place pry bar between frame and leaf spring and apply pressure to test looseness | Install new rubber bushings (some equipped with metal bushings) |
| Squeaky noise (slowing down or stopping) | Shock absorber | Linkage joints | Examine for lack of lubrication | Lubricate linkage |
| Rattle (from vicinity of wheels) | Shock absorbers | Loose on frame—Arm striking frame or other parts. Bushings or attaching eyes (telescoping type) worn or loose | Visual examination of parts. (Also check spring shackles, sway bar mounting and spring U-bolts for looseness) | Tighten bolts, align parts or rebush attaching parts. (Noise seldom within shock absorber itself) |
| **REAR AXLE NOISE** | | | | |
| Humming noise (continuous) | Rear axle pinion and drive gear | Pinion bearing incorrectly adjusted giving high tooth contact | Best done by driving on asphalt road. (Have correct seasonal lubricant in axle). Often can be tire noise | Move pinion towards drive gear (drive gear may require shifting also). Axle must be "taken down" for work |
| Gear noise (decelerating) | Rear axle Differential | End play in differential bearings excessive | Audible when releasing accelerator and car slows down | Rear axle must be opened. Loosen bearing saddle clamps and adjust bearings. Lock assembly |

*Continued*

**TABLE A (Continued)**

| CHARACTERISTIC SOUND OR BEHAVIOR | PART OR PARTS AFFECTED | PROBABLE NATURE OF TROUBLE | CHECKING | REMEDY |
|---|---|---|---|---|
| **REAR AXLE NOISE** | | | | |
| Hum while coasting | Axle wheel bearings | Excessive end play in axle shafts (or both shafts) | Audible when coasting. Jack up rear wheels and pull and push on wheels in line with axle shaft | Remove wheel, brake drum and adjust end play with shims inside backing plate |
| Noise or Growl on turns | Rear axle side gear thrust washers or inner axle oil seal | Thrust washers worn, seal burned out | Most audible when making left turn | Remove, disassemble differential and install new thrust washers (perhaps gears also). Install new axle oil seal |
| Chatter (limited Slip Differential only) | Differential clutches | Improper lubricant | Most audible in turns | Draw all old oil out with siphon. Refill with limited slip oil. |
| **BRAKE, TIRES AND WHEEL NOISE** | | | | |
| Chatter (applying brakes) | Brakes (one or more wheels) | Loose wheel bearing. Loose spring U-bolts. Loose spring shackle | Jack up wheel, grasp it top and bottom and test for "play." Inspect U-bolts for tightness. Test shackles | Adjust wheel bearing. Tighten U-bolts. Re-bush spring shackles |
| Loud squeal—when applying brakes | Brakes | Non-concentric shoes produce local high pressure areas. Drums distort under braking pressure | Remove wheels and brake drum. Check lining for uneven wear spots. Have mechanic check drums with gauges | Have shop true-up brake shoe linings with lining grinder. Install new brake drums |
| Squeal or whistle (on curves) | Tires | Lateral slippage caused by front wheel misalignment | Check tires for uneven tread wear, scuffing and cupped condition; check for bent frame | Front end alignment for toe-in camber, caster and king pin inclination. Straighten frame |
| Thumping noise | Tires | One or more tires "egg-shaped" | Jack up wheel; place carton or box on ground close to center of tread. Rotate tire slowly; note variation in distance between tire and box | Tire should be retrued (new tires should be driven 1500 miles or so for breakin before truing) |
| Rattle (front wheel) | Bearings | Broken ball or roller | Remove bearings and make visual inspection | Install new bearing assembly and adjust bearing |
| **BODY NOISE** | | | | |
| Rumble or Rattle (front end) | Hood | Hood fastener has insufficient spring tension<br><br>Anti-rattlers missing | Testing for trouble is also the cure. Loosen lock nut and turn dowel inward with screwdriver for correct fit and tighten nut. Check for missing rubber or fabric anti-rattlers | Correct tension removes "play"<br><br>Install new anti-rattlers |

| | | | | |
|---|---|---|---|---|
| Squeak | Door panel | Panel scrapes against hinge pillar | Look for "rusty" or shiny edge on door panel and hinge pillar | Open door, insert screwdriver in crack and press on door so as to close against it. Metal will spring back at flange |
| Front fender "squeak" | Fender and door | Too little clearance between fender and door | Visual inspection | Loosen bolts (engine compartment) holding fender rear edge to cowl. Shift fender forward or rearward with pinch bar for clearance, tighten bolts |
| Rattle (cowl) | Ventilator | Gasket rotted out or deteriorated | Visual inspection of gasket | Remove old pieces of gasket, clean channel, fit new gasket |
| Squeal or whistle (40-50 mph) | Body louvers on side of car | Air stream passing through louvers | Fasten a cloth over louvers and see if noise ceases | Break up air stream with wire fastened lengthwise in louvers |
| Rumbling sound | Doors and body panel | Vibration due to insufficient sound deadening | Difficult to check | Undercoating possibly best answer |
| Bumping noise (rear end of car) | Spare wheel and tire | Loose in its mounting. Loose body bolts | Visual inspection | Tighten clamp screw or nut. Tighten body bolts |
| "Buzzing" sound | Speedometer | Cable tip not correctly seated in speedometer head drive gear. Cable too long | Unscrew sleeve on rear of speedometer and examine parts | Seat tip into drive gear and tighten sleeve. Install cable of correct length. |

**TABLE B**

The dictionary says this about different kinds of noises:

**GROWL** To utter a deep guttural sound

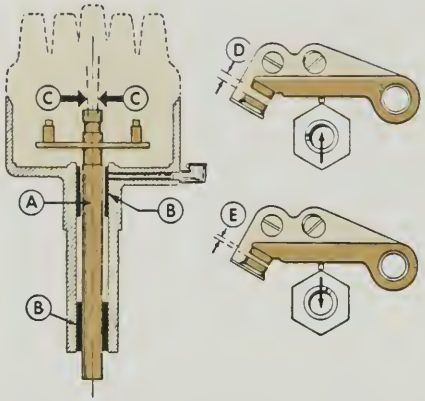
**HUM** A low monotonous noise...of a swiftly revolving top or a whirling wheel.

**KNOCK** ...a knocking noise as from loose parts knocking against each other.

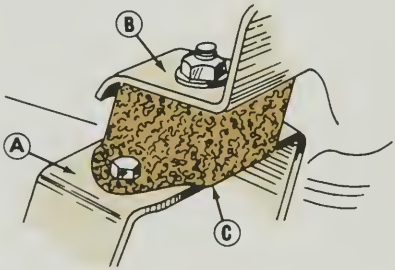
**SQUEAK** A sharp, shrill, piercing noise as of wheels turning on dry axles.

**THUMP** A blow or knock as with something thick or heavy . . . to cause a dull sound.

**RATTLE** To make, cause or emit a rapid succession of short, sharp noises as through shaking or recurrent collisions of hard bodies.




*Engine's "wump, wump, wump" at idle may be caused by a worn or bent ignition distributor shaft. Note how shaft (A) in top bushing (B) wobbles so its center line oscillates from C to C. As distributor cam is pushed toward or away from contact point breaker arm, point opening is either too great (D) or too little (E).*




*Typical forward engine mounting. (A) frame bracket; (B) engine; (C) rubber shock dampening insulator. If rubber deteriorates, a knock or thump may result as the engine rocks during accelerating.*

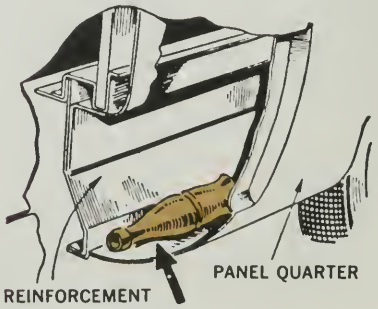
small noises you never have heard before at lower speeds.

When trying to locate noises under the hood and coming principally from the engine, a sounding rod helps to localize the source. The rod can be 5/16 or 3/8-inch diameter steel, and about three feet long, or use a broom stick of about the same length. To "sound" a noise, place one end of it on the spot to be tested and bring the other end close so your ear rests on your closed hand. To organize your attack, split up the engine section into zones.

While using the sounding rod, "short out" the spark plug of the cylinder being tested. If the engine knock becomes less audible, louder or changes in any way with a spark plug dead, you are pretty sure to have located the troublesome cylinder. Of course, if all connecting rod bearings are worn and loose, you will hear a clatter no matter where you put the end of the sounding rod on the crankcase. Speeding up the engine makes such clatter louder.

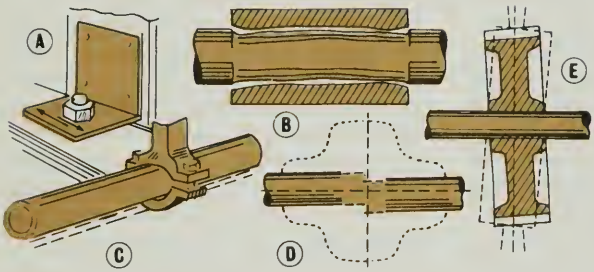
Actually the foreign noises we are interested in are those "funny sounds"—klunks, whistles and squeaks that might come from any part of your car.

Since many car owners recognize run-of-the-mill knocks, spark rap, valve tappet clatter, hydraulic valve lifter click, carbon knock and such, we'll skip those and talk about the ones that are harder to track down.




*A "mysterious" rattle like this soda bottle which some factory employee unthinkingly welded in the panel quarter is usually found only by sheer accident.*

*A little lubricant in the right place can prevent unwanted chirps and tweets from developing as parts, such as door push button, grow older. Do not oil lock, which requires a graphite lubricant.*




*A few causes of knocks, squeaks, and rattles. (A) friction of loose, dry parts rubbing together; (B) excessive wear in a shaft and its bearing or bushing; (C) loose part, like muffler tail pipe; (D) misaligned shafts, causing excessive wear and "pound"; (E) gears, pulleys, etc., that run out-of-true.*

Table A lists the more common noises, parts affected, probable trouble, how to check for it and how to fix it. You can't always apply the same information to every make of car. Take #9, if the car has an automatic transmission, you can't check for end play as prescribed because there is no pedal to push. In this case check for excessive end play with the oil pan off using a heavy screwdriver or pinch bar between the main bearing cap and crank cheek. Or, in #13, piston slap may occur in even a new or rebuilt engine with some types of aluminum pistons when the engine is cold, but the pistons will quiet down as the engine reaches correct operating temperature.

Whether you call it a knock, squeak, hiss, rattle, or pound (see Table B for definitions), a noise can be caused by one or more of the conditions illustrated. Friction will set up a squeak, for example, when a bolt becomes loose enough to allow adjacent parts to rub together. Squirting a little oil around the parts usually quiets it, but

for a permanent remedy, tighten the bolt. Friction, too, produces the squeak from a glazed fan belt. A little wax or aerosol belt dressing on the belt quiets it for a time, but you really need a new belt.

Out-of-round parts that wobble or hop can produce a wump-wump-wump noise like an out-of-balance wheel or engine flywheel. One grumble, accompanied by noticeable car vibration, is often traced to an unbalanced propeller shaft with undercoating on one side. Undercoating is fine for fenders or gas tank, but if a blob gets smeared on the propeller shaft (actually a tube), it can set up a mighty unpleasant vibration at high speeds. Since the undercoating is not evenly spread around shaft, it runs lop-sided—the higher the speed the worse it gets. It takes only a few ounces on the shaft to cause a noise.

An out-of-round or worn ignition distributor shaft can cause your car's engine to run "rough," particularly at low speed, along with a sort of "loping" exhaust. Wear can turn the bushing oval allowing the distributor shaft to be pushed back and forth in the oval opening by pressure from the bent shaft. In a six-cylinder engine distributor, for example, only two of the cylinders have the correct "dwell" or closure time for the contact points. Other cylinders are firing "early" or "late," causing an unbalanced or "rough" running engine.

Misaligned parts, such as two shaft ends which do not slide concentrically into a coupling, cause severe strains on the supporting bearings and wear the bearings excessively to produce noise. Clutches, transmissions, propeller shafts and rear axles are subject to these misalignments, particularly on older cars or those recently repaired. Transmission noises are difficult to track down because some noises, which seem to be coming from the transmission, actually are being "telegraphed" from their origin in the rear axle.

Adjustments for correcting misaligned parts are provided, for example, at the hood hinges, hood lock dowel and guide. Usually elongated holes at hood hinges permit fore and aft movement of the hood hinge brackets. To align hood, loosen hinge adjusting screws, grasp front of hood and shift it around until it is centered. Then carefully raise the hood and tighten the hinge screws.

Minor adjustments can be made on the trunk lid at the hinges. To find out if an adjustment is necessary, chalk the edge of the body flange with white chalk and close the lid. If chalk marks on the weatherstrip are not visible all around (spotty), adjustment is necessary. Loosen hinge support bolts and shift the deck lid in elongated holes at the body hinge support brackets. After alignment, tighten the bolts.

Shock absorbers are often blamed for noise when actually the fault may be elsewhere. There may be loose parts in the car's trunk, or spring shackles and clips may be loose. Fenders or bumpers may require tightening. Most shock absorber noise results from units that are empty or low in fluid, have worn links and bushings or loose mountings. Simplest way to correct shock absorber noise is to replace units.

In addition to curing rattles and noises, there are some things you can do to keep some parts of your car from developing unwanted chirps as they age.

These include windshield wiper arm pivots, door hinges, hood hinges and door push buttons (not the locks), which should be given a squirt of engine oil.

Other alternatives are door strikers (a stick lubricant), window channels (aerosol silicone lube), door lock and speedometer cable (graphite lubricant), hood latch (grease), spring shackles and shock absorber bushings (brake fluid), fender skirts (silicone lube) and pedal linkages (aerosol silicone lube).

*See also:* ENGINE; PARTS REPLACEMENT, ENGINE; UPHOLSTERY.

➤ *Use an epoxy patching putty to repair dent in auto body. Before putty is applied, dents are hammered or pulled out as much as possible, then sanded down to the bare metal. Two holes are where sheet metal screws were driven part way in to pull metal out.*

# How to Repair Dents and Rust-outs

**You can use a kit to fill minor dents and rusted-out spots in your car's body**

YOU DON'T NEED a professional auto body shop to repair small dents, rust-outs and deep scratches. Body repair products designed for easy use by car owners are available, and with just a bit of care, you can do a job with which you'll be thoroughly satisfied.

If you tried body patching years ago with the fiberglass kits and gave up because they were difficult to use, make another try with today's epoxy products.

No special tools are necessary, and everything you need should cost only a few dollars. In some cases, you may find complete kits in the automotive departments of discount houses.

The items required are: four grades of sandpaper (40, 80, 240 and 400 grit), filler putty, putty hardener (sold with the putty in all cases), metallic tape, a sanding block and a putty applicator (doctor's tongue depressor or equivalent).

If the problem is a small dent, hammer it out if possible; the less putty you have to use to fill a dent, the more durable the repair. Dents in fenders often can be knocked out with a hammer in back, and a block of wood held against the front.

Dents that cannot be hammered from the back (because of lack of access, such as in doors, or inadequate swing room for the hammer) can be pulled out by drilling small holes across the dent, inserting sheet metal screws and then pulling on the screws with a claw hammer. A piece of hardwood should be used to brace the back of the hammer.

After pulling out the dent to as close to the original surface line as possible, clean the area with a wax and grease remover, and sand the surface with coarse paper (40 grit) down to bare metal. It is now ready for filling with putty, which is described later.

If the problem is a rust-out begin by cleaning the body around it with a wax and grease remover, then remove metal particles from the rust-out, breaking off any pieces of metal that have been rust-weakened. Sand a two-inch border around the rustout with 40 grit paper, down to bare metal.

At this point, you have two choices for bridging the gap of the rust-out: 1) you can use wire mesh (as fine a screen as you can get) coiled up inside the space behind the rust-out. The mesh, which has a certain amount of springiness, should be much larger than the rust-out opening. Coil it, slip it in and it will unwind and cover the hole from the inside. Note: this type of repair is recommended for rocker panels only, but inasmuch as they are the most common rust-out problems, the method is useful. 2) you can use a metallic tape patch. To do this, crimp the edges of the rust-out inward with a screwdriver (this will create a depression in the border area). Cut a patch larger than the rust-out but smaller than the depression created by the crimping. Apply the patch, trimming if necessary with a razor blade. With 40 grit paper, feather the edges of the patch to the sheet metal.

Most body putties come in tubes and must be mixed with a hardening fluid just before application. Follow the instructions for proportions of putty to hardener very carefully. One popular body kit specifies that you squeeze out two beads of putty side by side and just touching, and run a thin stream of hardener in the valley they form.

Mix the putty and hardener very thoroughly with a stick and apply over the dent or rust-out. Apply enough putty and just shape it approximately with the stick. Once the putty dries and hardens, you can sand it down. Remember, it's a lot easier to sand down than to mix more putty and apply it to depressions.

*In one patching kit, two beads of putty are squeezed out side by side and touching. The valley between them is filled with hardener from a separate tube.*

*To use a tape patch on a rusted out spot, first remove all rusted metal. Then sand a two-inch border around the hole down to the bare metal. When this is done, use a screw driver, as shown, to crimp the edge of the hole inward.*

▲ *Apply metallic patching tape to the prepared hole, trimming it so the patch is larger than the hole, but smaller than the depression around the hole that was formed by crimping.*

▼ *Apply patching putty to damaged area, making sure you use enough. It is easier to sand off excess than it is to apply additional putty later on. Applicator here is a piece of plastic, but anything convenient will do.*

▼ *Sand patch to give it a feathered edge with the sheet metal of the body.*

▲ *Once patch has hardened, use sandpaper on block to shape it and bring it flush with the surrounding metal. Initial sanding can be with coarse grit, but use 80 grit for final work before painting with primer.*

*Use an aerosol retouching paint, and hold can about eight inches away to get an even coat.*

*After the repaired area has received a final coat of touch-up paint, wait a week and polish it.*

*Use wire mesh to provide support for putty when patching a rusted out rocker panel. Use a lot of mesh. Roll up tight and insert in rusted out area. It has some springiness and will uncoil slightly to press itself against rust-out.*

*One-part putties are available to fill deep scratches or nicks in surface, such as these.*

*Patching putty has been applied to dent. Dent and the area around it has been sanded.*

*Patched dent is sanded to desired shape with a block. Then apply a coat of primer.*

Hardening time for the putty depends on air temperature, how well you prepared the putty and how thick a layer of putty you applied. The thicker the layer and the lower the temperature, the longer it will take. Allow up to several hours on a cool day.

Once the putty is hard and dry, sand it down and shape it with coarse sandpaper on a sanding block. Do final shaping with medium paper (80 grit).

Apply a coat of primer paint. Use an aerosol type and hold the can at least eight inches away for even application. When the primer dries, sand the surface with wet very fine paper (240 grit) and wipe clean. Apply a second coat of primer and sand with wet extremely fine (400 grit) paper.

Again wipe the surface and apply coats of touchup paint (an aerosol is recommended). Several thin coats will produce a nicer result than one heavy coat.

After a week, rub the repaired area with a polish (not a wax). A month after the repair, clean and wax the entire car.

Deep body scratches can be filled with spot putty, a special compound that doesn't require mixing.

Begin by sanding the scratch down to bare metal with medium paper (80 grit). Mask the area and apply a coat of primer. When the primer dries, sand with wet very fine paper (240 grit) until smooth. Apply the spot putty to fill in the scratch.

When the putty dries, sand smooth with wet very fine paper (240 grit). Wipe clean and apply a second coat of primer. When the primer dries, sand to a smooth surface with extremely fine paper (400 grit). Wipe the surface clean and spray on the touch-up paint.

A week later, polish the repair. P.W.

*See also:* PAINTING, AUTO; PAINT SPRAYERS.

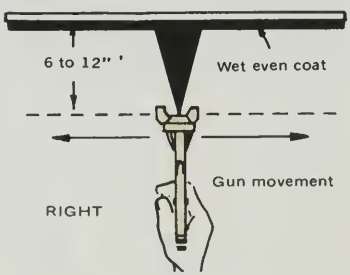
*Spray painting is an easy way to achieve a smooth, even coat on furniture, cars, or other irregular surfaces. Keep the gun moving to avoid sags and runs.*

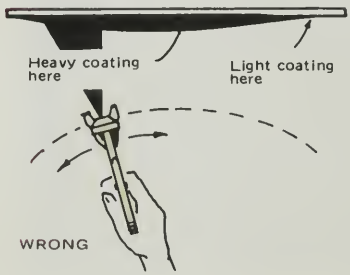
# All about Paint Sprayers

**These devices cost more than brushes or rollers, but they can speed the work and enable you to do a factory-smooth job**

PAINT SPRAYING OUTFITS range in price from around $5 to $300 or more, with popular home-owner models averaging in the $50 range. And, the familiar vacuum cleaner spray gun attachment is definitely not to be underrated. (Many of them can paint the exterior of a six-room house in a weekend.)

Compressors that operate the units are of three types. The piston compressor (for heavy duty pro outfits) provides the highest pressures and ranks at the top of the price list. The diaphragm compressor (with a diaphragm like the one in your car's fuel pump) ranks next, and is probably the most popular amateur type. The rotor compressor, operating like a supercharger, is in the low price bracket, but highly efficient within its performance range.



The self-contained vibrator pump is a cigarette-sized unit built into the gun itself, to operate from house current alternations and drive paint directly through the spray nozzle. It's one of the lowest priced types and one of the easiest to use, but it's not suited to heavy-bodied materials.

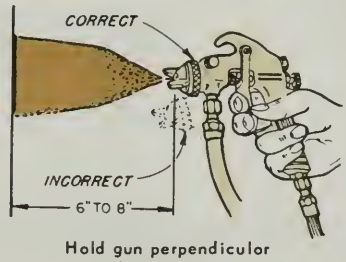
The car-engine compressor is probably the lowest priced form of spray gun air supply. It's threaded to replace a spark plug in your car's engine and utilize the cylinder's compression stroke to operate a matched spray gun. In most types wadded cotton or fiberglass in the screw-in unit trap oil vapor that might otherwise travel through the air line to the gun. One-way valves in the unit plus an air space within it minimize pulsation.

The gas cartridge gun, good for rough, everyday jobs on outdoor furniture, masonry, etc., operates from a $CO_2$ siphon bottle cartridge of the type available at large drugstores. It needs no air line or electric cord and can function anywhere from roof to crawl space. A single gas cartridge will spray a full 21-ounce container of paint.

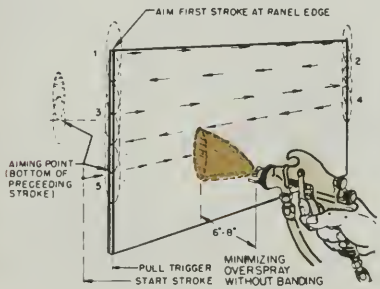
Vacuum cleaner sprayers, often included with the cleaner's original equipment, can otherwise be added for around $5. These, like other spray guns designed to make the most of a limited air supply, are of the pressure type. The air forces the paint out of the container and through the spray nozzle. With greater air pressure, a siphon type gun is often used. In this, the air stream from the nozzle passes over the tip of the feed tube from the paint container with such velocity that it sucks the paint out.

There are two basic nozzle types. The internal-mix nozzle is best for heavy, slow-drying finishes like house paint that won't harden inside the nozzle. The external-mix nozzle is best with quick-drying finishes like automobile lacquer. As the finishing material is broken into a spray outside the nozzle by cross streams of air from outside jets, it can't be clogged inside. The internal-mix nozzle can be used only with pressure feed guns; external-mix with pressure or suction feed.

Triggering systems are of two general types. One is termed the bleeder type. It shuts off the paint only, allowing the air to continue escaping through the gun even when the trigger is released. This is the type to use with the small homeowner compressor that does not have a pressure release valve. As the air flows freely at all times (whether spraying or not), there is no danger of back pressure on the compressor with possible motor overload or diaphragm strain. The escaping air also can be used to "blow away" sags and spread overly heavy applications. Used with skill (as it is by many pros in auto body shops), the air stream can easily cure many a spray painting mistake. (Many pro guns provide for air stream use even though both paint and air can be triggered off.)



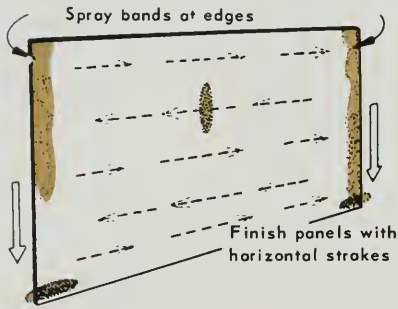

Hold gun perpendicular to surface being sprayed.

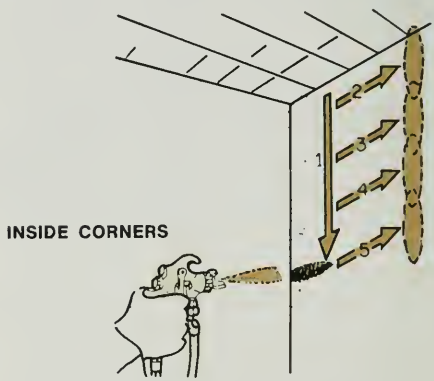


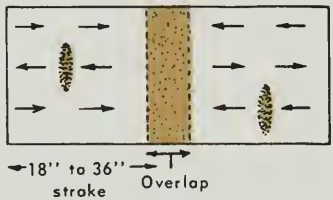
Non-bleeder guns shut off air and paint immediately when the trigger is released. These are used with high pressure compressor systems (as in garages and body shops) where the compressor has its own pressure release and automatic shut-off. A bleeder gun on this system would simply waste air pressure.

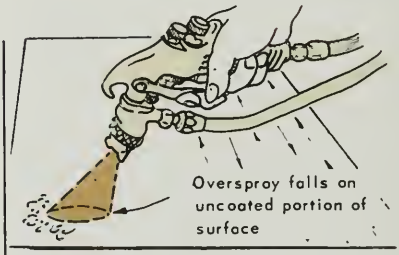
Convertible guns enable you to take advantage of most of the features of the various kinds of sprayers, according to the type of compressor and other equipment you use, you can switch from bleeder to non-bleeder, from pressure feed to suction feed and from one nozzle type to another.

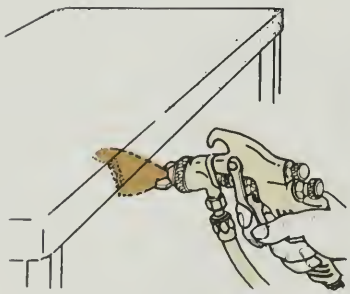
Spray patterns made by the guns are either round or oval. An internal-mix gun

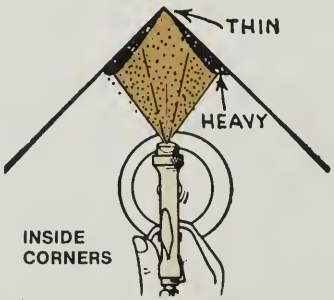


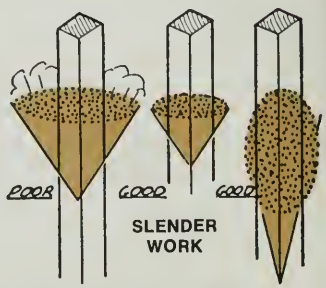





Banding edges




SPRAYING SQUARE GIVES UNEVEN COATING BUT IS SATISFACTORY FOR MOST WORK




AVOID EXCESSIVE OVERSPRAY—MAKE PATTERN FIT. CENTER EXAMPLE IS BEST FOR MOST JOBS

with a round nozzle makes a round pattern. Give it a slotted nozzle and it makes an oval or "fan" pattern. Generally, you get both nozzle types with this form of gun. Some even include an angled nozzle that lets you spray upward at about 45° to ease ceiling jobs without tilting the gun so much it is likely to spit droplets on the surface.

External-mix guns make an oval pattern because of the "horns" that send cross streams of air across the spray, flattening it from round to oval when they hit it. If the horns are in vertical position they make a horizontal oval. If they are in horizontal position they make a vertical oval.

*About air pressure.* For heavy-bodied paints that you might use in painting your house, you'll do best with a compressor that can put out around 35 pounds per square inch pressure, though pressure-feed guns let you lower the figure, as in the case of the usual vacuum cleaner attachment. When pressure is lowered appreciably, the paint must be thinned to match. (Make a few tests.) Often this calls for an extra coat. But you still retain the characteristic spray gun smoothness of finish—if you work with care.

On light-bodied paints you can get by with less air pressure. And some finishes work best at lower pressures, such as multicolor paints that form their best pattern at around 12 to 18 pounds per square inch.

In any spray gun work the results point clearly to any errors in technique or use of equipment. If you have excessive clouds of overspray you have too much pressure. On most compressor setups, you can regulate it with a simple adjustment. (Those lacking the adjustment usually are designed so they cannot build up more than normal pressure.) If your sprayed paint shows runs or sags down the painted surface you have either thinned the material too much or you are holding your gun too close to the surface—perhaps not moving it fast enough across the paint area.

If you are spray painting for the first time, take a few minutes to do a little practicing on a cardboard carton. The smooth surface will show your errors quickly and save many a headache when you tackle the actual job. And it will also save you plenty of paint.

*Holding the gun.* Chief bugaboo in spray painting is uneven movement of the gun and variation in the distance from gun to sprayed surface. If you hold the gun stationary, even for a moment, paint will build up on the surface in front of it and cause sags. If you hold the gun too close to the work, you're likely to have much the same result. Held too far away, it's likely

FAULTY PATTERNS AND HOW TO CORRECT THEM

<table>
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<td> </td>
<td>Cause<br>Dried material in side port "A" restricts passage of air through port on one side. Results in full pressure of air from clean side port in a fan pattern in direction of clogged side.<br>Remedy<br>Dissolve material in side port with thinner. Do not probe in any air nozzle openings. with metal devices.</td>
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<td>Cause<br>Dried material around the outside of the fluid nozzle tip at position "B" restricts the passage of atomizing air at one point through the center ring opening of the air nozzle. This faulty pattern can also be caused by loose air nozzle, or a bent fluid nozzle or needle tip.<br>Remedy<br>If dried material is causing the trouble remove air nozzle and wipe off fluid tip, using rag wet with thinner. Tighten air nozzle. Replace fluid nozzle or needle if bent.</td>
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<td>Cause<br>A split spray pattern (heavy on each end of a fan pattern and weak in the middle) is usually caused by: (1) atomizing air pressure, too high, (2) attempting to get too wide a spray with thin material, (3) not enough material available.<br>Remedy<br>(1) Reduce air pressure. (2) Open material control "D" to full position by turning to left. At the same time turn spray width adjustment "C" to right. This reduces width of spray but will correct split spray pattern.</td>
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</table>

Cause

(1) Air entering the fluid supply.
(2) Dried packing or missing packing around the material needle valve which permits air to get into fluid passageway.
(3) Dirt between the fluid nozzle seat and body or a loosely installed fluid nozzle.
(4) A loose or defective swivel nut, siphon cup or material hose.

Remedy

(1) Assure all fittings and connections are tight.
(2) Back up knurled nut (E), place two drops of machine oil on packing, replace nut and finger tighten. In aggravated cases, replace packing.
(3) Remove fluid nozzle (F), clean back of nozzle and nozzle seat in gun body using rag wet with thinner, replace nozzle and draw up tightly against body, using the proper tool.
(4) Tighten or replace swivel nut (G).

Cause

A fan spray pattern that is heavy in the middle, or a pattern that has an unatomized "salt-and-pepper" effect indicates that the atomizing air pressure is not sufficiently high, or there is too much material being fed to the gun.

Remedy

Increase pressure from air supply. Correct air pressures as discussed elsewhere in this manual.

to cause "orange-peel" texture in the painted surface. Hold it at the proper distance from the surface and *keep it moving* and you'll get the smoothest surface you're likely to produce with any painting tool. But it takes more know-how than brushing or rolling.

*How to pick a sprayer.* For overall spraying jobs, including those of a major nature from house painting to car painting, you can use a good diaphragm-type compressor with a mated gun. For heavy-duty use, as in professional work, favor a piston compressor. It can produce higher pressures and needs little attention over long operating periods.

For small touch-up jobs, like refinishing car scratches or repainting small tools, you can get by with one of the car-cylinder or tire-pressure spray guns. For intermediate use—the jobs that don't require a compressor, but are too big for the car-cylinder

*Painting a portion of an automobile with a spray gun.*

units—pick a vibrator-pump self-contained gun.

Whatever gun you select will enable you to do the factory-smooth type of work you find on cars and appliances. And it also can do a job in spraying insecticides on shrubs and trees.

There's an easy way, too, to heal the first scratch on your new car—when you have no paint to match it. Put a little lacquer thinner in your spray gun and spray it carefully on the scratch from one side. (Put a scratch on some unimportant lacquered item first, for a test.) The thinner flows the lacquer already on the surface across the scratch, closing it in and making it invisible. That alone is worth the price of the outfit.

*See also:* FLOORS; PAINT; PAINTING; PAINTING, AUTO; PAINTING, HOUSE.